F5 | Marine Ecology

Mangroves
Dugongs and Turtles
Potential Coral Loss

Santos | PETRONAS

Report

LNG Facility

Marine Ecology

NOVEMBER 2009

Prepared for

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Table of Contents

4 Part 4 Potential Coral Loss

Tables

3 Part 3 Dugong and Turtle Management Plan

4 Part 4 Potential Coral Loss

Figures

2 Part 2 Mangroves

3 Part 3 Dugong and Turtle Management Plan

4 Part 4 Potential Coral Loss

Plates

4 Part 4 Potential Coral Loss

Appendices

3 Part 3 Dugong and Turtle Management Plan

Abbreviations

Abbreviation	Description
AHD	Australian Height Datum
AIM	Audit and Inspection Manager
AIMS	Australian Institute of Marine Science
AQIS	Australian Quarantine and Inspection Service
AVTAS	AIMS Video Transect Analysis System
CAF	Curtis Island Accommodation Facility
CITES	Convention on International Trade in Endangered Species
CMS	Conservation of Migratory Species
CPIC	Common Pipeline Infrastructure Corridor
CSD	Cutter Suction Dredge
Cwlth	Commonwealth
DDT	dichlorodiphenyl-trichloroethane
DERM	Department of Environment and Resource Management
DEWHA	Department of the Environment, Water, Heritage and the Arts
DMP	Dredge Management Plan
DMPF	Dredge Material Placement Facility
DPI&F	Department of Primary Industries and Fisheries
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EPBC	Environmental Protection and Biodiversity Conservation Act 1999
FHA	Fish Habitat Area
FHMOP	Fish Habitat Management Operational Policy
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
GDA	Geocentric Datum of Australia
GLNG	Santos Ltd/PETRONAS Gladstone LNG Project
GPA	Gladstone Port Authority
GPC	Gladstone Ports Corporation
GSDA	Gladstone State Development Area
GTP	Gas Transmission Pipeline
ha	hectare
IAS	Initial Advice Statement
IFO	Independent Fauna Observer
IMS	Incident Management System
kHz	KiloHertz
LAT	Lowest Astronomical Tide
LNG	Liquefied Natural Gas
m	metre
m^3	cubic metre
MOF	Materials Offloading Facility
MSL	Mean Sea Level
Mt	Mega ton

Abbreviation	Description
Mtpa	Mega ton per annum
NC	Nature conservation
PCB	polychlorinated biphenyl
PLF	Product Loading Facility
QDEH	Queensland Department of Environment and Heritage
Qld	Queensland
QPWS	Queensland Parks and Wildlife Service
RE	Regional Ecosystems
ROW	Right of Way
Santos	Santos Limited
SCUBA	self contained underwater breathing apparatus
SE	standard error
SPRAT	Species Profile
T&DMP	Turtle and Dugong Management Plan
TBT	Tri-butyl-tin
TSHD	Trailer Suction Hopper Dredge
URS	URS Australia Pty Ltd
WA	Western Australia
WBD	Western Basin Dredging
WHA	Workforce Health Assessor

Part 1 Introduction

1

1.1 Mangroves

Santos Limited (Santos) is proposing the development of a liquefied natural gas (LNG) liquefaction and export facility at Hamilton Point West in the south-west section of Curtis Island, near Gladstone, Queensland. Detailed descriptions of the proposed activities associated with the proposed Gladstone LNG (GLNG) Project are contained in the GLNG EIS. As part of the GLNG Project, Santos proposes:

- The installation of a gas transmission pipeline (GTP), (and possibly a bridge) across the Narrows;
- The construction of an LNG facility at Hamilton Point West; and
- The development of a Dredge Material Placement Facility (DMPF) in a bay south of Laird Point for the disposal of the dredge spoil generated.

Part 2 of this report has been prepared for inclusion into the GLNG Supplementary Environmental Impact Statement (EIS) to address several comments received during the public consultation phase of the EIS. The comments requested:

- Further detail on the extent of mangroves to be removed;
- Further detail on the loss of intertidal habitat; and
- Discussion on potential recovery timeframes.

Potential impacts to intertidal seagrass meadows as a result of dredging are described and discussed in **Attachment G5**). The direct and potential indirect loss of mangroves and intertidal habitat due to the construction and operation of the DMPF is discussed in **Attachment G7***.*

This report details the potential direct and indirect loss of mangroves and intertidal habitat due to the construction and operation of the LNG facility and the GTP crossing of the Narrows. The mangroves and intertidal areas at risk from direct and indirect impacts have been calculated using the Regional Ecosystems (RE) and Essential Habitat mapping resources provided by the Queensland Department of Environment and Resource Management (DERM). A discussion on potential recovery timeframes is also included.

1.2 Dugong and Turtle Management Plan

The main objective of Part 3, Turtle and Dugong Management Plan (T&DMP), is to describe how potential impacts to turtles and dugongs from GLNG project activities will be managed. Specifically, the T&DMP will provide:

- The project management team with evidence of practical and achievable plans to ensure that the project's environmental requirements with respect to turtles and dugongs are complied with;
- An integrated plan for monitoring, assessing and controlling potential impacts to turtles and dugongs;
- Local, State and Commonwealth authorities with a framework to confirm compliance with policies and requirements; and
- The community with evidence that the GLNG project will be managed in an environmentally acceptable manner.

This T&DMP will be reviewed and updated, as necessary, to reflect knowledge gained during the course of the project's construction and operations. Changes to the T&DMP will be implemented in consultation with the relevant authorities where necessary.

1.3 Coral

Santos Limited (Santos) is proposing the development of a liquefied natural gas (LNG) liquefaction and export facility at China Bay in the south-west section of Curtis Island, near Gladstone, Queensland. As part of the proposed Gladstone LNG (GLNG) project, Santos proposes capital dredging of approximately 6,8 millions m^3 for a shipping channel and swing basin, and approximately 100,000 m^3 for an access channel to the proposed Materials Offloading Facility (MOF).

URS Australia Pty Ltd (URS) prepared the Environmental Impact Statement (EIS) for the GLNG Project. The EIS included descriptions of rocky reef habitats in the vicinity of Hamilton Point located to the south of the proposed LNG facility (GLNG EIS section 8.4.4.5 and Appendix R1).

Following the release of the EIS, the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) requested further quantitative data on the rocky reef communities be included in the Supplementary EIS. In response to this request, URS deployed a field team to collect additional data on the rocky reefs.

The primary objective of the survey included as Part 4 was to provide quantitative data on the rocky reef communities potentially impacted by dredging activities associated with the development of the LNG facility.

The report provides data on the major habitat types encountered and fauna observations.

Part 2 Mangroves

Report

Mangrove and intertidal areas potentially affected by the LNG facility, the Laird Point DMPF and the pipeline crossing the Narrows

NOVEMBER 2009

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Reference:	42626457/01/C
Status:	FINAL

Table of Contents

Tables

Figures

Abbreviations

Abbreviation	Description
CPIC	Common Pipeline Infrastructure Corridor
DERM	Department of Environment and Resource Management
DMP	Dredge Management Plan
DMPF	Dredge Material Placement Facility
DPI&F	Department of Primary Industries and Fisheries
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
FHMOP	Fish Habitat Management Operational Policy
GLNG	Gladstone LNG
GSDA	Gladstone State Development Area
GTP	Gas Transmission Pipeline
LNG	Liquefied Natural Gas
MOF	Materials Offloading Facility
PLF	Product Loading Facility
RE	Regional Ecosystems
ROW	Right of Way
Santos	Santos Limited
TSS	Total Suspended Solids

Introduction

1.1 Background

Santos Limited (Santos) is proposing the development of a liquefied natural gas (LNG) liquefaction and export facility at Hamilton Point West in the south-west section of Curtis Island, near Gladstone, Queensland. Detailed descriptions of the proposed activities associated with the proposed Gladstone LNG (GLNG) Project are contained in the GLNG EIS. As part of the GLNG Project, Santos proposes:

- The installation of a gas transmission pipeline (GTP) and possibly a bridge across the Narrows;
- The construction of an LNG facility at Hamilton Point West; and
- The development of a Dredge Material Placement Facility (DMPF) in a bay south of Laird Point for the disposal of the dredge spoil generated.

This report has been prepared for inclusion in the GLNG Supplementary Environmental Impact Statement (EIS) to address comments received during the public consultation phase of the EIS. The comments requested:

- Further detail on the extent of mangroves to be removed;
- Further detail on the loss of intertidal habitat; and
- Discussion on potential recovery timeframes.

Potential impacts to intertidal seagrass meadows as a result of dredging are described and discussed in Attachment G5. The direct and potential indirect loss of mangroves and intertidal habitat due to the construction and operation of the DMPF is discussed in Attachment G7.

This report details the potential direct and indirect loss of mangroves and intertidal habitat due to the construction and operation of the LNG facility and the GTP crossing of the Narrows. The mangroves and intertidal areas at risk from direct and indirect impacts have been calculated using the Regional Ecosystems (RE) and Essential Habitat mapping resources provided by the Queensland Department of Environment and Resource Management (DERM).

1.2 Intertidal habitat

Mangroves and salt marshes grow in the intertidal zone of quiet estuaries and bays, protected from strong currents and wave action. Salt marshes are frequently associated with mangroves and abut against them, with saltmarsh growing inshore of the mangroves (Hutchings & Saenger, 1987). The mangrove zone occurs inshore of sand and mud flats. This strong zonation typifies Port Curtis intertidal areas and is common on Curtis Island. These distinct communities occur generally parallel to the shore, except where drainage channels or creeks alter the surface topography (Chamberlain, 1979).

Following is a brief overview of mangrove and saltmarsh/saltpan communities. The EIS contains detailed descriptions of these communities, along with discussions on potential impacts and mitigation measures (see EIS Section 8.4 and EIS Appendix R1).

1.2.1 Mangrove Communities

Mangrove communities are considered ecologically important for a number of reasons (Galloway, 1982; Connell Wagner, 2008; UNEP-WCMC, 2006). It is considered that they:

- Support recreational and commercial fisheries by providing essential nursery, feeding and breeding areas for many species of fish, invertebrates and migratory birds;
- Facilitate biologically productive natural systems by contributing organic matter to estuaries;

- Act as a filter of sediments and other substances that may accumulate from land runoff;
- Provide important buffering against natural and/or anthropogenic processes, including overland runoff, flooding and storms;
- Provide key areas for educating the community and the general public on the nature and significance of coastal wetlands (http://www.derm.qld.gov.au); and
- Assist in oxygenating substrates through the root systems of mangrove communities.

The buffering capacity of mangrove communities protects the near shore environment from influences such as flooding, sedimentation, eutrophication and pollutants (UNEP-WCMC, 2006).

1.2.2 Saltmarsh Communities

Saltpans are hypersaline, unvegetated areas high in the intertidal zone that are inundated only at high spring tides. They are characterised by poorly drained clay soils, high evaporation rates and a low, highly seasonal rainfall (Saenger, 1996). The surface of the saltpan is devoid of vascular plants, but can be covered by a thick algal mat. The mat combines with the top layer of clay to form a leathery surface which peels off and cracks into sheets as the saltpan dries (Olsen *et al*., 1980).

In Port Curtis, saltmarsh occurs at the seaward edge of extensive saltpans, usually just landward of mangroves. Saltmarsh can also occur at the terrestrial side of salt flats where freshwater input reduces salinity (Morrisey, 1995).

Although saltpan environments are generally only inundated with the high tides they can play an important role as fisheries habitat. These communities can be an important nursery and/or feeding area for smaller fish species. Saltpans may also support a diverse invertebrate assemblage, including crustaceans, molluscs and insects. These assemblages are important food sources for a number of species, including species of commercial and recreational value (Morrisey, 1995).

1.2.3 Regional Extent of Mangrove and Saltmarsh/Saltpan Communities

Curtis Island is located within the Burnett-Curtis Hills and Ranges subregion (which is part of the South East Queensland Bioregion). The RE mapping for the Burnett-Curtis Hills and Ranges subregion (which includes Curtis Island) lists a total of 16,580 hectares (ha) of mangroves and 15,242 ha of saltpan/saltmarsh (DERM 2009).

The mangrove and intertidal areas at Friend Point are located within the Marlborough Plains subregion (which is part of the Brigalow Belt bioregion). The RE mapping for the Marlborough Plains subregion lists a total of 54,700 ha of mangroves, 12,015 ha of *Sporobolus virginicus* grasslands, and 71,251 ha of samphire forbland.

Danaher *et al*., (2005) mapped total intertidal habitats within the Narrows and Port Curtis region and reported that there were 6,376 ha of mangroves and 4,380 ha of saltpan/samphire communities.

1.3 GLNG Activities

1.3.1 LNG Facility

The construction of the LNG facility (Train 1) (including the marine facilities) is expected to take approximately four years, commencing in 2010, with operations planned to commence in early 2014.

1 Introduction

EIS Section 3.8.2.2 contains details of the LNG facility construction, including site preparation activities expected to commence in mid 2010.

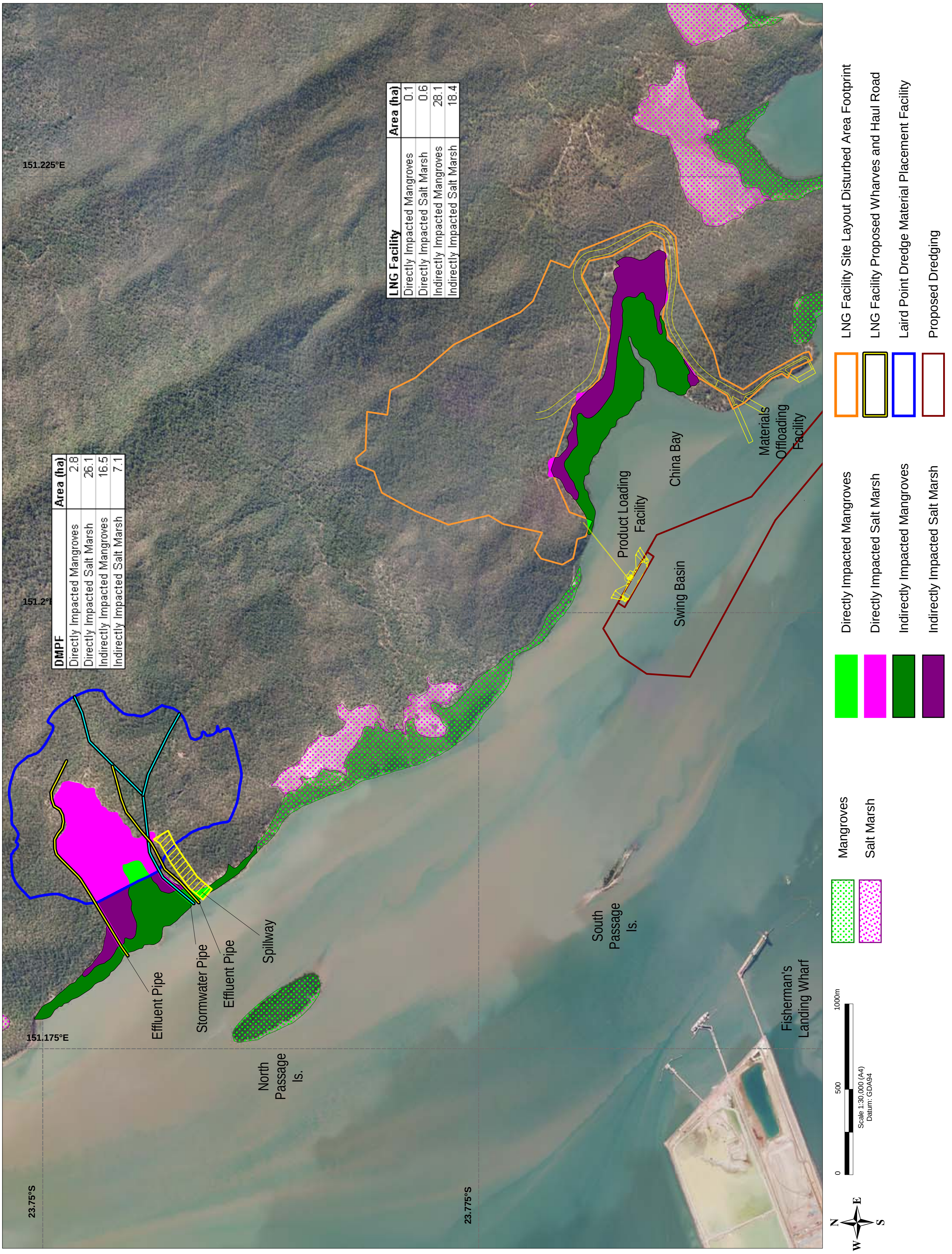
The activities relevant to this report are the construction of the LNG facility, the Product Loading Facility (PLF), the Materials Offloading Facility (MOF) and haul roads. shows the proposed LNG facility, along with areas of mangroves and saltmarsh/saltpan potentially impacted.

1.3.2 Gas Transmission Pipeline

The GTP will cross Port Curtis between Friend Point (mainland side) and Laird Point (Curtis Island side). On the mainland side, there are two alternative approaches to Friend Point; the Gladstone State Development Area (GSDA) Common Pipeline Infrastructure Corridor (CPIC) (CPIC (GSDA Section) Route), and the GLNG GTP (September 2009) within the GSDA (see Figure 1-2).

Pipeline construction will be within a 40 m right of way (ROW). It is assumed that all vegetation within this ROW will be cleared. The vegetation assessments conducted as part of the EIS and Supplementary EIS have included the mapping of communities within a 200 m wide buffer area (including the 40 m ROW). It is assumed that the buffer areas (outside of the ROW) will not be affected.

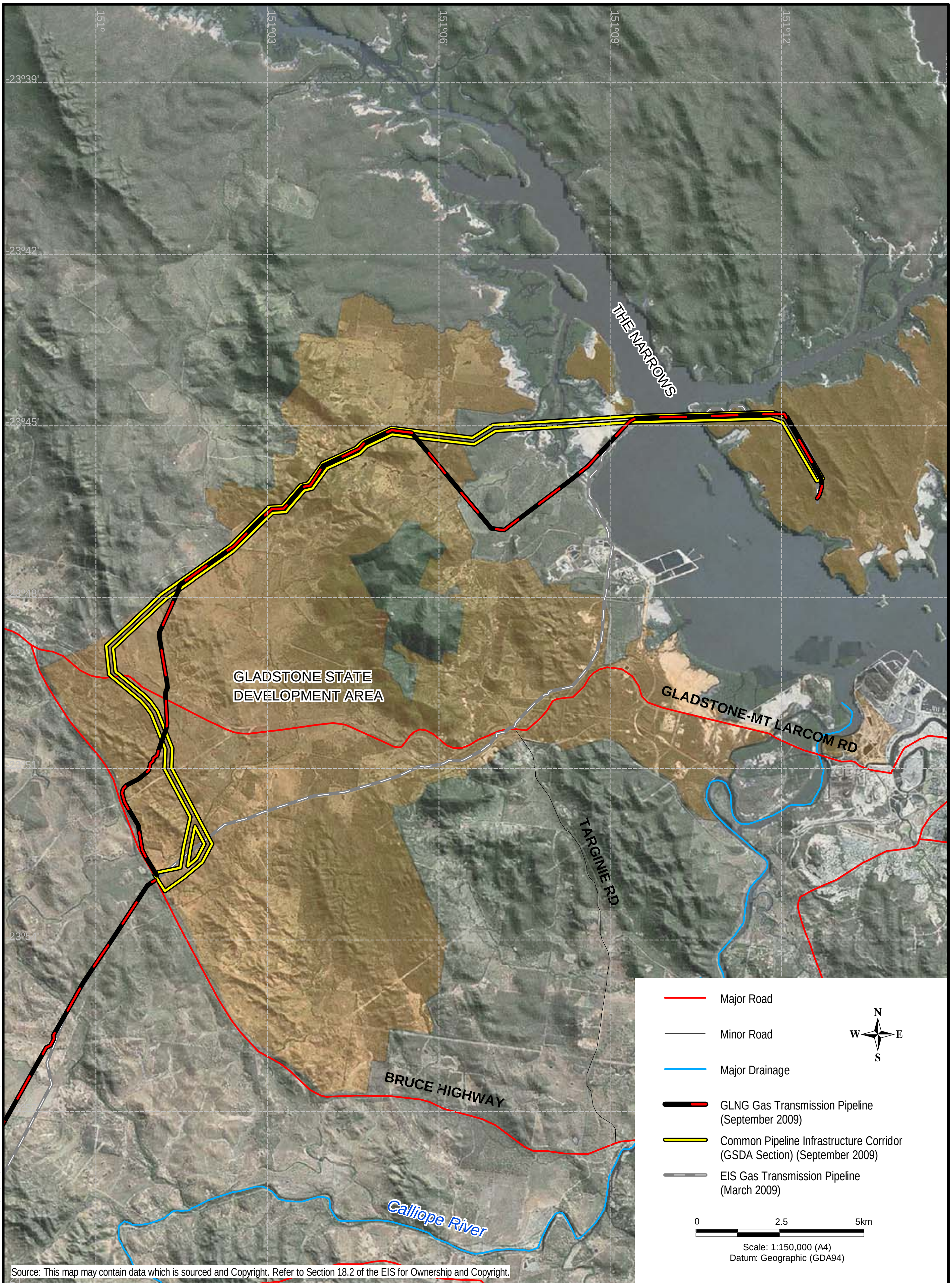
Note: If the proposed bridge is built, it will be along a similar alignment as the proposed pipeline. For the purposes of this report, the mangrove and intertidal areas potentially affected would be the same.



DMPF	Area (ha)
Directly Impacted Mangroves	2.8
Directly Impacted Salt Marsh	26.1
Indirectly Impacted Mangroves	16.5
Indirectly Impacted Salt Marsh	7.1

LNG Facility	Area (ha)
Directly Impacted Mangroves	0.1
Directly Impacted Salt Marsh	0.6
Indirectly Impacted Mangroves	28.1
Indirectly Impacted Salt Marsh	18.4

Client	Project GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY MANGROVE ASSESSMENT	Title **LNG FACILITY POTENTIAL IMPACTS TO MANGROVES AND SALT MARSH COMMUNITIES**
URS	Drawn: CA Approved: JB Date: 22-10-2009 Job No: **4262 6440**/6220 File No: 42626440-g-2074.wor	Figure: **1-1** Rev: B **A4**



Client	Project	Title
LNG URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY MANGROVE ASSESSMENT	**GAS TRANSMISSION PIPELINE CROSSING AT THE NARROWS**

Drawn: RG	Approved: JB	Date: 12-11-2009	Figure: **1-2**	Rev:A
Job No: **4262 6440/6220**	File No: 42626440-g-2185.wor			**A4**

Potential Impacts and Mitigation Measures

2.1 Potential Impacts

Direct impacts include the clearing and resultant loss of mangroves and saltmarsh/saltpan as a result of construction activities associated with the LNG facility and pipeline crossing of the Narrows.

Indirect impacts which may occur include: degradation of habitat due to increased sedimentation; altered local hydrology; pollution or potential disturbance of acid sulphate soils; and indirect impacts to fauna breeding and feeding activities (Stewart & Fairfull, 2008; Connell Wagner, 2008). Potential pollution impacts and mitigation measures are discussed in Attachment F3. Potential acid sulphate soils impacts and mitigation measures are discussed in Attachment E5. Potential fauna impacts and mitigation measures are discussed in Part 3 of Attachment F5 (Dugong and Turtle Management Plan).

2.1.1 Increased Sedimentation

A very important feature of mangrove forests is their ability to trap and bind sediment within their extensive root structures (Saenger, 1982). Under a moderate sedimentation rate, a mangrove forest will accelerate the process of land formation (Cahoon *et al*., 2002). Too much sedimentation, on the other hand, can lead to mangrove mortality as the sediments asphyxiate the respiratory structures (e.g., lenticels and aerenchyma) which mangroves have developed to allow for gas exchange within the roots (Cahoon *et al*. 2002; Duke 2006). Therefore, there is the potential for either an increase in the area available for mangrove colonisation, or the potential for sedimentation to result in mortality of mangroves in the area.

Mangroves can normally adjust to natural accretion conditions by growing longer pneumatophores or more stilt roots (Hutchings and Saenger, 1997). Smothering by sediment can also cause increased stress to mangroves depending on the depth and numbers of pneumatophores covered. Natural recolonisation has occurred in the lesser affected areas. Elevated levels of TSS from capital dredging is expected to be localised and short-term (refer Attachment G5). Deposition rates of sediment have also been calculated and potential impacts to mangroves from increased sedimentation caused by elevated levels of TSS from capital dredging are likely to be low.

2.1.2 Coastal Processes

Construction and operation of the LNG facility and the pipeline crossing of the Narrows may alter existing surface water drainage patterns adjacent to mangroves with potential negative effects, such as build-up of sediments resulting in depletion of dissolved oxygen in the sediments (Pollard & Hannan, 1994; Stewart & Fairfull, 2008). Since mangroves acquire their oxygen via their root system, anaerobic sediments can lead to mortality and loss of key fish habitat. Altered water courses and drainage can also affect the salinity of these ecosystems. Saltmarshes in particular do not tolerate constant freshwater inputs (Duke, 2006; Nybakken & Bertness, 2005). Hence, frequent freshwater inputs may potentially negatively impact adjacent saltmarsh communities.

2.1.3 Recovery from Sedimentation and altered Hydrology

Minor disturbances to mature mangrove and saltmarsh communities in protected estuaries are generally self repairing, but major disturbances can result in altered coastal dynamics and make recovery problematic. At this latitude mangroves grow quickly and have the potential to recover effectively from such removals (Stewart & Fairfull, 2008). In the interim the saltmarsh behind the mangroves can become exposed to pollutants and freshwater inputs and can be lost in a secondary coastal damage scenario (Morrisey, 1995).

Mangroves and saltmarsh require gradated shorelines that can dissipate wave energy and allow periodic invasion of saltmarsh by seawater (Morrisey, 1995; Duke, 2006; Field, 2004). Mangrove and saltmarsh coastlines need sufficient buffer area to provide for retreat and advance phases that naturally occurs over time (Xiaolin & Quiaomin, 1997).

Overall trends in recovery of mangroves and salt marshes are not clear given the nature of these sediments and potential altered hydrodynamics resulting from the dredging activities (Cahoon *et al*., 2002).

Mangroves will not establish or survive along high energy coastlines. Mature mangroves will however survive medium and infrequent tidal energy episodes, especially where retreat and advancement space is available (Morrisey, 1995; Duke, 2006; Field, 2004). In this case, the coastline will not be subjected to significant clearance; so the considerable supply of propagules coming from the surrounding areas is very likely to enhance the re-settlement of mangroves in areas potentially impacted (Saenger, 1982).

In the unlikely event that the tidal energy may be too severe for seedlings to establish naturally, replanting techniques may then be required (Saenger, 1982; Weir *et al*., 2006). In addition, consideration may need to be given to additional construction of controlled coastal inundation mechanisms to ensure conditions required for healthy mangroves and saltmarshes are retained or created where losses have occurred (Pollard & Hannan, 1994) (Brisbane City Council conducted some trials in Brisbane River).

2.2 LNG Facility

2.2.1 Direct Impacts

Figure 1-1 shows the areas of mangrove and saltmarsh/saltpan that would be directly and potentially indirectly impacted by the construction of the LNG facility, PLF, MOF and haul roads. The direct loss (i.e. through clearing) has been calculated to be 0.61 ha of saltmarsh/saltpan and 0.12 ha of mangroves. This is equivalent to 0.004 % of the mapped saltmarsh/saltpan and 0.001 % of mangroves within the RE subregion (as shown in Table 2-1). Table 2-2 shows the percentage loss when compared against the mapping of Danaher, *et al*. (2005); equivalent to 0.014 % of saltpan/samphire dominated saltpan, and 0.002 % of mangrove communities.

Table 2-1 Area and proportion of loss of mangroves and saltmarsh/saltpan communities directly affected (DERM Regional Ecosystem mapping)

Regional Ecosystem (RE)	Vegetation Community Description	Area in LNG facility study area (ha)	Area within subregion (ha)[1]	% of subregion
12.1.2	Saltpan vegetation comprising *Sporobolus virginicus* grassland and samphire herbland on Quaternary estuarine deposits	0.61	15,242	0.004

2 Potential Impacts and Mitigation Measures

Regional Ecosystem (RE)	Vegetation Community Description	Area in LNG facility study area (ha)	Area within subregion (ha)[1]	% of subregion
12.1.3	Mangrove shrubland to low closed forest on Quaternary estuarine deposits	0.12	16,580	0.001

[1] Derived from RE data for the Burnett-Curtis Hills and Ranges subregion as per Accad et al. (2006)

Table 2-2 Areas and proportion of loss of mangroves and saltmarsh/saltpan communities according to (Danaher et al. 2005)

Vegetation Community Description	Area in LNG facility study area (ha)	Area within Port Curtis/ Rodds Bay (ha)	% of area
Saltpan / samphire dominated saltpan	0.61	4,380	0.014
Mangrove communities	0.12	6,736	0.002

2.2.2 Potential Indirect Impacts

Potential indirect impacts to adjacent mangroves and saltmarsh/saltpan in close proximity to the proposed LNG facility, PLF, MOF and haul roads may occur (refer Figure 1-1). 18.44 ha of saltmarsh/saltpan and 28.09 ha of mangroves are found adjacent to the LNG Facility and associated infrastructure footprint. In the event that all of these communities are indirectly impacted by construction and operation of the LNG facility, 0.121 % of the mapped saltmarsh/saltpan and 0.169 % of mangroves within the RE subregion will be impacted (Table 2-3), or 0.421 % of saltpan/samphire dominated saltpan and 0.417 % of mangrove communities within mapped areas conducted in Danaher *et al*., (2005) report (Table 2-4).

Table 2-3 Areas of mangroves and saltmarsh/saltpan communities not directly affected but in close proximity (RE mapping)

Regional Ecosystem (RE)	Vegetation Community Description	Area in LNG facility study area (ha)	Area within subregion (ha)[1]	% of subregion
12.1.2	Saltpan vegetation comprising *Sporobolus virginicus* grassland and samphire herbland on Quaternary estuarine deposits	18.44	15,242	0.121
12.1.3	Mangrove shrubland to low closed forest on Quaternary estuarine deposits	28.09	16,580	0.169

[1] Derived from RE data for the Burnett-Curtis Hills and Ranges subregion as per Accad et al. (2006)

Table 2-4 Areas of mangroves and saltmarsh/saltpan communities not directly affected but in close proximity (Danaher et al. 2005)

Vegetation Community Description	Area in LNG facility study area (ha)	Area within Port Curtis/ Rodds Bay (ha)	% of area
Saltpan / samphire dominated saltpan	18.44	4,380	0.421
Mangrove communities	28.09	6,736	0.417

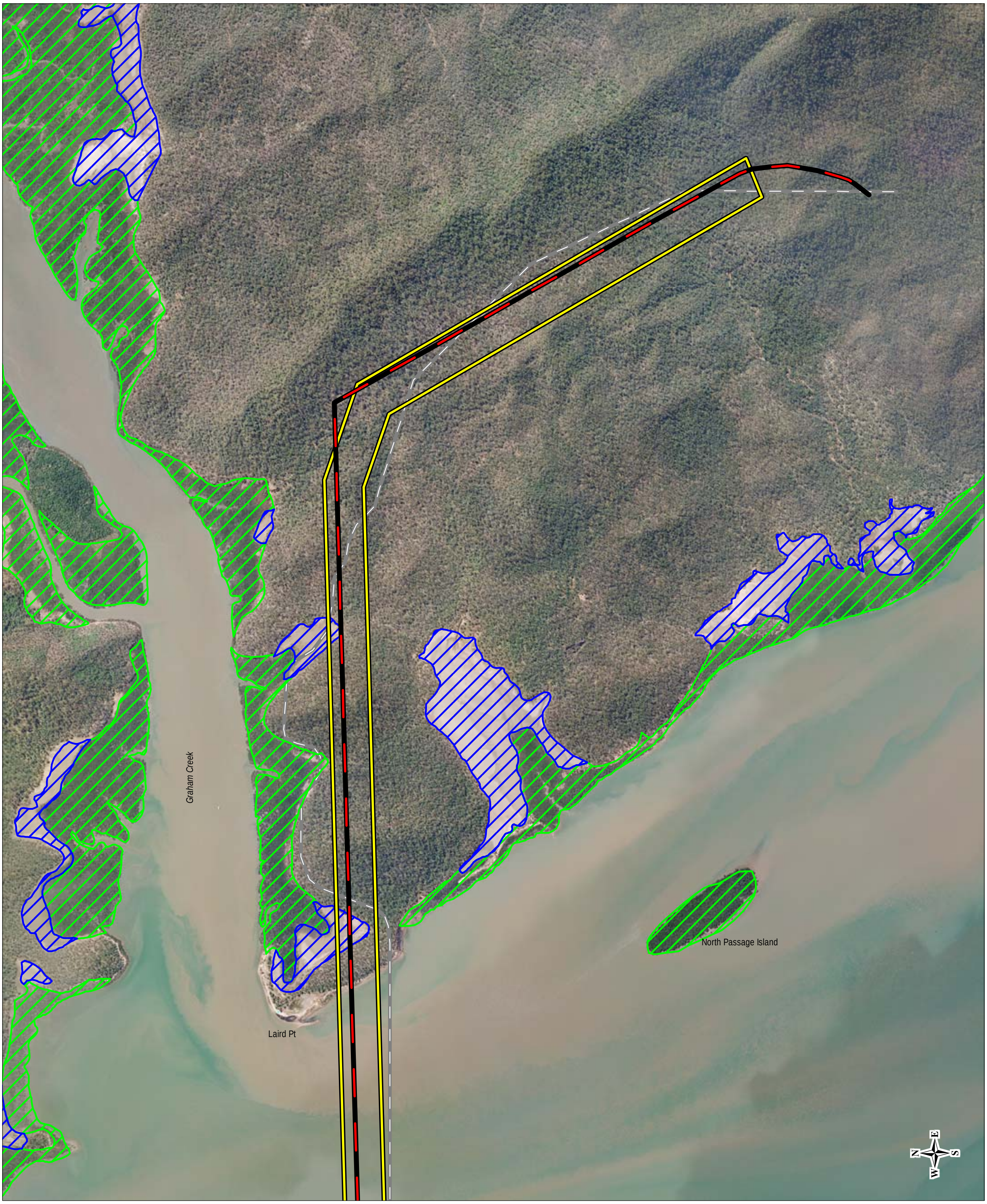
2.3 Gas Transmission Pipeline

2.3.1 Curtis Island (Laird Point)

Figure 2-1 shows the pipeline corridor at Laird Point on Curtis Island with RE mapping overlaid.

The clearing of the ROW within the GTP corridor would result in the loss of 3.93 ha of saltmarsh/saltpan. This is equivalent to 0.026 % of the Burnett-Curtis Hills and Ranges RE subregion (Table 2-5) or 0.090 % of the saltpan/samphire dominated saltpan mapped by Danaher *et al*., (2005) (Table 2-6).

Indirect impacts to mangrove and saltmarsh/saltpan areas outside of the ROW are expected to be minimal.



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Projection: Geographic (GDA94)

GLNG Gas Transmission Pipeline (September 2009)

Common Pipeline Infrastructure Corridor (GSDA Section) (September 2009)

EIS Gas Transmission Pipeline (March 2009)

Mangroves

Salt Marsh

Source:This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY MANGROVE ASSESSMENT	**GAS TRANSMISSION PIPELINE CORRIDOR ON CURTIS ISLAND (LAIRD POINT)**
	Drawn: RG Approved: JB Date: 13-11-2009	Figure: **2-1** Rev:A
	Job No: **42626440/**6220 File No: 42626440-g-2186.wor	**A4**

Table 2-5 Areas of mangroves and saltmarsh/saltpan communities directly affected (RE mapping)

Regional Ecosystem (RE)	Vegetation Community Description	Area in Laird Point study area (ha)	Area within subregion (ha)[1]	% of subregion
12.1.2	Saltpan vegetation comprising *Sporobolus virginicus* grassland and samphire herbland on Quaternary estuarine deposits	3.93	15,242	0.026

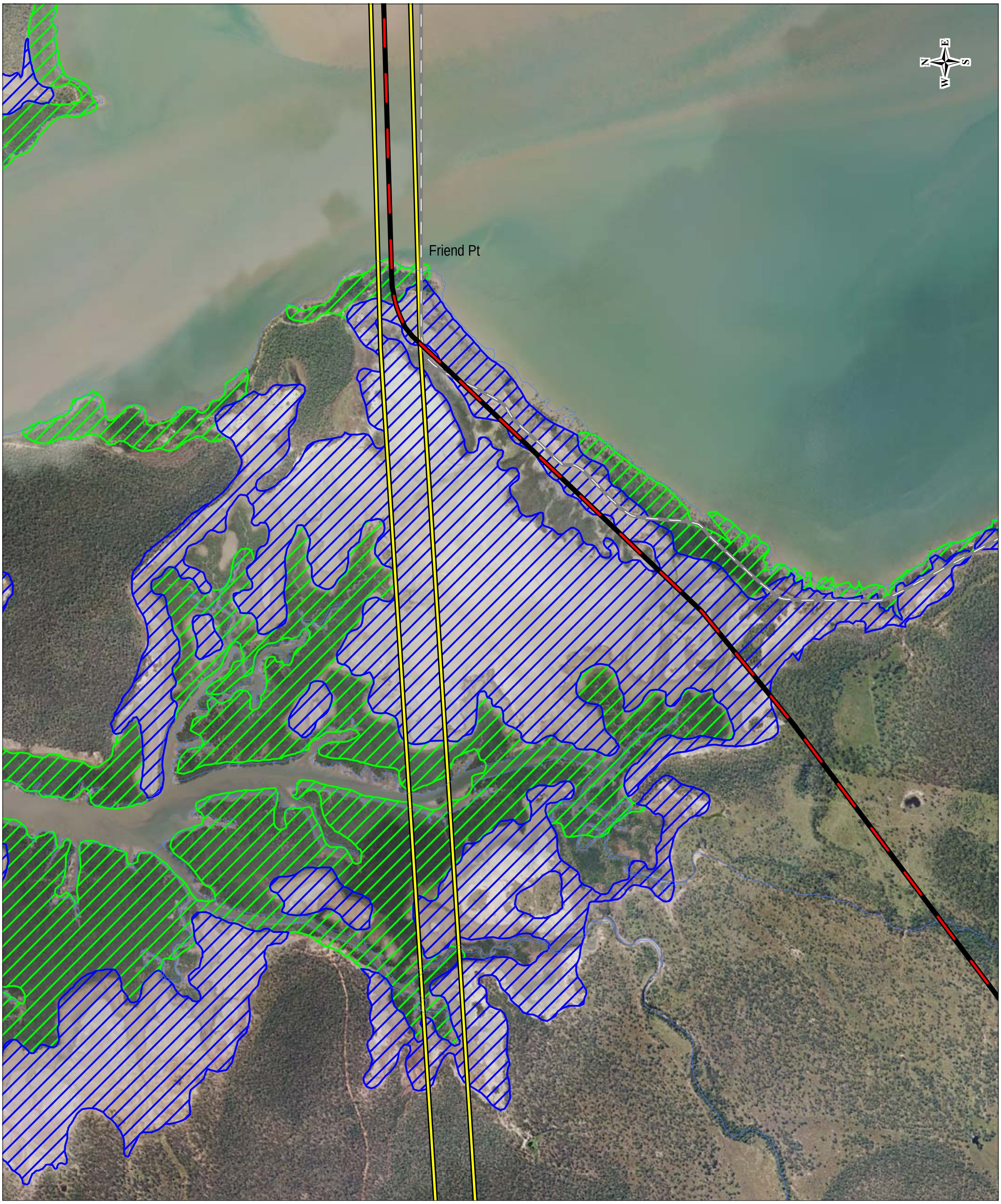
[1] Derived from RE data for the Burnett-Curtis Hills and Ranges subregion as per Accad et al. (2006)

Table 2-6 Areas of mangroves and saltmarsh/saltpan communities directly affected (Danaher et al. 2005)

Vegetation Community Description	Area in Laird Point study area (ha)	Area within Port Curtis/ Rodds Bay (ha)	% of area
Saltpan / samphire dominated saltpan	3.93	4,380	0.090

2.3.2 Mainland (Friend Point)

Figure 2-2 shows the options being considered for the pipeline approaching Friend Point with RE mapping overlaid.



GLNG Gas Transmission Pipeline (September 2009)

Commonn Pipeline Infrastructure Corridor (GSDA Section) (September 2009)

EIS Gas Transmission Pipeline (March 2009)

Major Drainage

Mangroves

Salt Marsh

0 500 1000m

Scale: 1:25,000 (A4)

Projection: Geographic (GDA94)

Source:This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY MANGROVE ASSESSMENT	**GAS TRANSMISSION PIPELINE CORRIDOR ON CURTIS ISLAND (FRIEND POINT)**

Drawn: RG	Approved: JB	Date: 13-11-2009	Figure: **2-2**	Rev:A
Job No: **42626440/**6220	File No: 42626440-g-2187.wor			**A4**

2 Potential Impacts and Mitigation Measures

Common Pipeline Infrastructure Corridor (CPIC)

The clearing of the ROW within the CPIC (GSDA Section) corridor would result in the loss of 0.36 ha of *Sporobolus virginicus* grassland, 10.04 ha of samphire forbland (i.e. 10.40 ha in total of saltmarsh/saltpan) and 3.60 ha of mangroves. This is equivalent to 0.003 % of the *Sporobolus virginicus* grassland, 0.014 % of the samphire forbland, and 0.007 % of mangroves within the Marlborough Plains RE subregion (Table 2-7) or 0.237 % of the saltpan/samphire dominated saltpan and 0.053 % of mangroves mapped by Danaher, *et al*. (2005) (Table 2-8).

Potential indirect impacts to mangrove and saltmarsh/saltpan areas outside of the ROW are considered to be minimal.

Table 2-7 Areas of mangroves and saltmarsh/saltpan communities directly affected by CPIC (GSDA Section) Route ROW (RE mapping)

Regional Ecosystem (RE)	Vegetation Community Description	Area in Friend Point study area (ha)	Area within subregion (ha)[1]	% of subregion
11.1.1	*Sporobolus virginicus* grassland on marine clay plains	0.36	12,015	0.003
11.1.2	Samphire forbland on marine clay plains	10.04	71,251	0.014
11.1.4	Mangrove forest/woodland on marine clay plains	3.60	54,700	0.007

1 Derived from RE data for the Marlborough Plains subregion as per Accad et al. (2006)

Table 2-8 Areas of mangroves and saltmarsh/saltpan communities directly affected CPIC (GSDA Section) Route ROW (Danaher et al. 2005)

Vegetation Community Description	Area in Friend Point study area (ha)	Area within Port Curtis/ Rodds Bay (ha)	% of area
Saltpan / samphire dominated saltpan	10.40	4,380	0.237
Mangrove communities	3.60	6,736	0.053

GLNG Gas Transmission Pipeline (GTP) (September 2009)

The clearing of the ROW within the GLNG GTP (September 2009) corridor would result in the loss of 1.43 ha of *Sporobolus virginicus* grassland, 8.89 ha of samphire forbland (i.e. 10.32 ha in total of saltmarsh/saltpan) and 0.70 ha of mangroves. This is equivalent to 0.012 % of the *Sporobolus virginicus* grassland, 0.012 % of the samphire forbland, and 0.001 % of mangroves within the Marlborough Plains RE subregion (Table 2-9) or 0.236 % of the saltpan/samphire dominated saltpan and 0.010 % of mangroves mapped by Danaher *et al*., (2005) (Table 2-10).

Potential indirect impacts to mangrove and saltmarsh/saltpan areas outside of the ROW are considered to be minimal.

Table 2-9 Areas of mangroves and saltmarsh/saltpan communities directly affected by GLNG GTP (September 2009) (RE mapping)

Regional Ecosystem (RE)	Vegetation Community Description	Area in Friend Point study area (ha)	Area within subregion (ha)[1]	% of subregion
11.1.1	*Sporobolus virginicus* grassland on marine clay plains	1.43	12,015	0.012
11.1.2	Samphire forbland on marine clay plains	8.89	71,251	0.012
11.1.4	Mangrove forest/woodland on marine clay plains	0.70	54,700	0.001

[1] Derived from RE data for the Marlborough Plains subregion as per Accad et al. (2006)

Table 2-10 Areas of mangroves and saltmarsh/saltpan communities directly affected by GLNG GTP (September 2009) (Danaher et al. 2005)

Vegetation Community Description	Area in Friend Point study area (ha)	Area within Port Curtis/ Rodds Bay (ha)	% of area
Saltpan / samphire dominated saltpan	10.32	4,380	0.236
Mangrove communities	0.70	6,736	0.010

2.4 Mitigation Measures

In accordance with the Department of Primary Industries and Fisheries (DPI&F) *Fish Habitat Management Operational Policy* (*FHMOP*) 005 (2002) *Mitigation and Compensation for Works or Activities Causing Marine Fish Habitat Loss*, mitigating actions such as best practice methodologies will be used to remove mangroves and saltmarsh to be potentially impacted by construction activities. Santos will discuss the options for appropriate environmental offsets under the Queensland Government Environmental Offsets Policy (2008) with the DPI&F and any other relevant agency to establish an offset agreement with the regulator.

Santos is committed to educating all staff and construction workers on the fisheries values of mangroves and saltmarsh and the protection of these values. Santos will also discuss with DPI&F the mitigation and environmental offsets options in accordance with the *FHMOP005* and the *Queensland Government Environmental Offsets Policy*.

A number of Environmental Management Plans (EMPs) have been developed for inclusion into the EIS Supplement. These include:

- Gas Transmission Pipeline EMP;
- LNG facility EMP;
- Marine Facilities EMP;
- Bridge, road and service corridor EMP; and
- Dredge Management Plan (DMP).

2 Potential Impacts and Mitigation Measures

These management plans include detailed management and mitigation measures for controlling potential impacts from construction and operation activities associated with the GLNG Project which may impact marine and/or intertidal areas.

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Part 3 Dugong and Turtle Management Plan

Report

Turtle and Dugong Management Plan

NOVEMBER 2009

Prepared for

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Table of Contents

Tables

Figures

Appendices

Abbreviations

Abbreviation	Description
AHD	Australian Height Datum
AIM	Audit and Inspection Manager
AQIS	Australian Quarantine and Inspection Service
CAF	Curtis Island Accommodation Facility
CITES	Convention on International Trade in Endangered Species
CMS	Conservation of Migratory Species
CSD	Cutter Suction Dredge
Cwlth	Commonwealth
DDT	dichlorodiphenyl-trichloroethane
DERM	Department of Environmental Resources Management
DEWHA	Department of the Environment, Water, Heritage and the Arts
DMP	Dredge Management Plan
DMP	Dredge Management Plan
DMPF	Dredge Material Placement Facility
DPI&F	Department of Primary Industries and Fisheries
DPA	Dugong Protection Agency
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EPBC	Environmental Protection and Biodiversity Conservation Act 1999
FHA	Fish Habitat Area
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
GLNG	Santos Ltd/PETRONAS Gladstone LNG Project
GPA	Gladstone Port Authority
GPC	Gladstone Ports Corporation
Ha	Hectare
IAS	Initial Advice Statement
IFO	Independent Fauna Observer
IMS	Incident Management System
kHz	KiloHertz
LAT	Lowest Astronomical Tide
m	Metre
Mm^3	Million cubic metres
MOF	Material Offloading Facility
Mt	Mega ton
Mtpa	Mega ton per annum
NC	Nature conservation
PCB	polychlorinated biphenyl

Abbreviation	Description
PLF	Product Loading Facility
QDEH	Queensland Department of Environment and Heritage
Qld	Queensland
QPWS	Queensland Parks and Wildlife Service
SPRAT	Species Profile
T&DMP	Turtle and Dugong Management Plan
TBT	Tri-butyl-tin
WA	Western Australia
WBD	Western Basin Dredging
WHA	Workforce Health Assessor

Executive Summary

Dugongs and marine turtles occur within the Port Curtis area. A desktop study was conducted to assess potential impacts from construction and operation phases of the GLNG Project including:

- The LNG facility and associated infrastructure;
- The Dredge Material Placement Facility at Laird Point;
- Capital and maintenance dredging operations; and
- Trenching of a gas transmission pipeline.

Measures to avoid interactions and mitigate behavioural changes of dugong and marine turtles and measures to reduce habitat degradation of the area are discussed.

Dugong (*Dugong dugon*) and marine turtles are listed on the 2000 IUCN (World Conservation Union) Red List of Threatened Animals and on Appendix I of CITES and Appendix II of the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) or Bonn Convention. Australia is signatory to both the IUCN and the CMS Conventions and recognises these agreements under the Australian Government's *Environment Protection and Biodiversity Conservation Act* 1999.

Port Curtis is wholly within the Rodds Bay Dugong Protection Area B (DPA), prescribed under the *Fisheries Act 1994* and its subordinate legislation that regulates commercial fishing activities. Recent studies indicate that high numbers of dugong are found within Rodds Bay DPA and forage on seagrass meadows within the Port (GHD, 2009) and that dugongs display fine scale movements between localised bays (Marsh and Lawler, 2006). Grech and Marsh (2007) classed the area around Gladstone as low to medium conservation status on the basis of relative density of dugongs estimated from spatial modelling and frequency analysis taken from time series data over 19 years of aerial surveys. Evidence of dugong feeding activity has been observed on the majority of intertidal seagrass meadows surveyed in Port Curtis during the 2007 DPI&F long term monitoring program (Chartrand *et. al*., 2009).

Nesting of flatback turtles (*Natator depressus*), green turtles (*Chelonia mydas*) and occasional nesting of loggerhead turtles (*Caretta caretta*) has been reported on the ocean side of southern Curtis Island and Facing Island (Limpus, 1999). Several green turtles were observed in Port Curtis during the field surveys conducted in 2008 and 2009 for the Santos GLNG EIS and it has been reported that The Narrows and the Calliope River mouth are major foraging areas (Connell Hatch 2006). Other studies indicate the loggerhead turtle and flatback turtle (*Natator depressus*) utilise habitats in the outer harbour and occasionally move northward through Port Curtis into The Narrows (QDEH & GPA, 1994). The beaches on the ocean side of southern Curtis Island and Facing Island support an important intermediate breeding population of flatback turtles (*Natator depressus*) (Limpus, 2007). The flatback turtle population utilising these beaches for nesting has remained consistent over 35 years of monitoring with approximately 50 females nesting annually (Limpus *et. al*., 2006). There are no recognised nesting beaches inside Port Curtis, with the closest sites being used by flatback (and occasionally green) turtles at North Cliff Beach (Facing Island) and the main beach at South End (Curtis Island), where annual numbers have been estimated at 25-50 per beach (QDEH & GPA, 1994).

Changes in the behaviour and potential interactions with dugong and marine turtles may occur from construction and operation of the GLNG Project. In this assessment, potential impacts to dugong and marine turtles are likely from the following activities:

- Increased sedimentation and turbidity from dredging resulting in temporary declines in water quality, habitat degradation and potential displacement of marine fauna in the local area;

- Noise and vibration from dredging, pile driving and trenching activities;
- Interactions by the dredge head;
- Boat strike and behavioural changes from increased vessel activity; and
- Changes in behaviour of nesting turtles and hatchlings from lighting and gas flaring.

Potential impacts from dredging activities are likely to be the most significant cause of habitat degradation in the marine environment. Interference from noise and vibration may cause dugong and turtles to avoid the area, resulting in reduced habitat quality and seagrass availability in the short-term.

Marine fauna observation procedures during dredging and piling operations will mitigate potential impacts to turtles and dugong although avoidance behaviour will be likely. Standard navigational controls for vessels will be employed and an agreed series of actions will be implemented should they be sighted within a specified distance of the dredger. A Dredge Management Plan has been developed in the EIS Supplement (Attachment G9) detailing mitigation measures to minimise the dredge footprint; monitor water quality conditions and use water quality triggers to halt dredging operations if declines in water quality exceed acceptable levels. Halting dredging operations may also occur in the event that turtles or dugong approach the dredge vessel within 50 m.

Potential impacts to seagrass meadows are considered to be short-term and minimal. The plume dispersion studies do not suggest that there will be measurable increases in suspended solids levels at the intertidal areas on Curtis Island or on the mainland adjacent to Fisherman's landing. The plume is anticipated to have decayed to within the range of normal background levels within 500m from the source point. To minimise the risk to the sensitive seagrass habitats, it is proposed to set suspended sediment threshold limits for the placement facility discharge and at representative sensitive receptor sites.

Increased risk to dugongs and marine turtles from vessel strike will result from the GLNG Project activities, particularly with large high speed vessels such as water taxi's. Controlled vessel speeds, maintaining constant watch and adhering to reporting requirements will be implemented to reduce any potential interactions during all phases of the project.

Potential impacts from flaring activities to nesting marine turtles are currently considered unlikely due to the location of turtle nesting beaches to the LNG facility site construction site and the intervening topography. Either a direct line of sight or glow may occur during gas flaring events from the LNG facility site to these beaches. Modification of lighting to mitigate potential impacts to turtles include reducing the intensity of light glow using low pressure sodium (LPS) lights; using timers and restricting the height of available light or applying shrouds to control direction.

Introduction

1.1 Objective

The main objective of this Turtle and Dugong Management Plan (T&DMP) is to provide an assessment of potential impacts of the GLNG Project on turtles and dugongs and describe how potential impacts will be managed. Specifically, the T&DMP will provide:

- The project management team with evidence of practical and achievable plans to ensure that the project's environmental requirements with respect to turtles and dugongs are complied with;
- An integrated plan for monitoring, assessing and controlling potential impacts to turtles and dugongs;
- Local, State and Commonwealth authorities with a framework to confirm compliance with policies and requirements; and
- The community with evidence that the GLNG Project will be managed in an environmentally acceptable manner.

This T&DMP will be reviewed and updated, as necessary, to reflect knowledge gained during the course of the project's construction and operations. Changes to the T&DMP will be implemented in consultation with the relevant authorities where necessary.

1.2 GLNG Overview

The EIS for the GLNG Project describes in detail the proposed developments, the existing environment, and potential impacts and mitigation measures. The activities which have the potential to impact turtles and dugongs are:

- Dredging of approach channels, swing basins and Materials offloading facility (MOF) areas;
- Construction of the proposed Product Loading Facility (PLF), North China Bay;
- Construction of a MOF and bund wall for the proposed dredge material placement facility (DMPF) at Laird Point;
- Disposal of dredge material at the DMPF at Laird Point;
- Installation of a gas transmission pipeline across Port Curtis from Friend Point to Laird Point;
- Construction and operation of the LNG facility;
- Vessel movements during all phases of the project; and
- Gas flaring.

1.2.1 Construction of the LNG Facility

The construction of the LNG facility (including the marine facilities and dredging) is expected to take approximately four years, commencing in 2010, with operations planned to commence in early 2014.

Section 3.8.2.2 of the GLNG EIS contains details of the LNG facility construction, including site preparation activities expected to commence in mid 2010. The necessary earthmoving equipment will be mobilised to Curtis Island by landing craft type vessels from the mainland. The EIS stated all material and personnel would be mobilised from Auckland Point, however ongoing project design refinements (in consultation with Gladstone Ports Corporation) have led to alternate "materials" loading areas being considered including the establishment of a temporary facility at Fisherman's Landing and a more permanent facility on a suitable site in the vicinity of the Calliope River (refer to Attachment L for further details). Vessels will land at the proposed MOF area and travel to the facility site via existing trails. As part of early works this equipment will be used to construct the MOF and haul road.

1.2.2 Product Loading Facility and Materials Offloading Facility

Section 3.8.2.3 of the EIS describes construction activities associated with the PLF. The PLF will include:

- Access trestle – approximately 300 m long piled structure over the water. The pipes on this trestle will connect the onshore plant to the offshore loading platforms;
- Loading platform with four loading arms for loading of LNG onto ships;
- Marine operations platform – for housing the marine terminal, which may be moved to onshore at a later stage in design;
- Building, electrical room, firewater pumps and stand-by generators, which may be moved to onshore at a later stage in design and the firewater supplied from an onshore tank; and
- Six mooring and four breasting dolphins.

Section 3.8.2.4 of the EIS describes construction activities associated with the MOF.

1.2.3 Dredging

Product Loading Facility

To enable LNG vessels to access the PLF it will be necessary for an access channel to be dredged from the existing Targinie Channel in Port Curtis which is currently used to provide shipping access to the RG Tanna Terminal and is to be extended to provide access to the proposed Wiggins Island Terminal.

The capital dredging comprises two parts; i) the dredging of a new North China Bay approach channel to the proposed LNG facility from the existing Targinie Channel and ii) the creation of a berthing and manoeuvring area at the LNG facility. The total volume to be dredged is 6.8 million m^3, the large majority of which (~5.7 million m^3) is associated with the creation of the berthing and manoeuvring area (refer to Attachment G9).

The approach channel will be dredged to a depth of -13.5 m LAT over a length of 1500 m and a channel width of 200 m giving a dredge footprint of 300,000 m^2. It will be dredged to a depth of -13.5 m below lowest astronomical tide (LAT). The existing bed levels vary between -6.6 m LAT and -12.1 m LAT. Therefore up to 6.9 m of material must be removed to achieve the required depth. This equates to a volume of approximately 1.1 Mm^3 of sand.

The new berth and manoeuvring area will also be dredged to -13.5m LAT at the PLF to enable ships to manoeuvre safely. The dredge footprint is approximately 620,000 m^2. Approximately 5.7 Mm^3 of sand and rock will be removed to lower the existing bed levels (between +0.7 m LAT and -10.2 m LAT) to the required depth (refer Attachment G9).

The proposed capital dredging locations are shown in Figure 1-1.

For the purposes of project planning and the EIS it has been assumed that dredging will be carried out within a period of 49 weeks, however, this period may vary depending on, for example, commercial factors. The Dredge Management Plan (DMP) (Attachment G9) also assumes a 49 week dredging period.

Due to the characteristics of the material to be dredged for the approach channel and swing basin and the presence of pockets of rock, the most technically suitable and cost effective dredging plant is a large or medium cutter suction dredge (CSD) (refer Attachment G9).

1 Introduction

Modelling results indicate that the potential impacts of dredging on sub-tidal communities are anticipated to be low. It should be noted however that the modelling results are based on dredging within the swing basin. Whilst this is the location for the majority of dredging activity (5.7 Mm^3), dredging will also be required for the approach channel (1.1 Mm^3) which will require positioning of the CSD in closer proximity to the soft coral communities for a period of approximately 8 weeks. During this period the potential impacts on soft coral communities are anticipated to be low to medium.

Capital dredging of the swing basin (5.7 $Mm^{3)}$ is expected to take approximately 41 weeks. Potential impacts to adjacent subtidal communities from elevated TSS are expected to be low.

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Datum : GDA 94

- GLNG Gas Transmission Pipeline (Sep. 2009)
- LNG Facility Indicative Site Boundary
- Dredge Delivery Line
- Dredge Material Placement Facility
- Proposed Dredging Channel

Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client	Project	Title	
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY DUGONG AND TURTLE MANAGEMENT PLAN	**DREDGE MATERIAL PLACEMENT FACILITY LOCATION**	
Drawn: MG	Approved: KK	Date: 03-11-2009	Figure: **1-1**	Rev. B
Job No.: **4262 6440**	File No.: 42626440-g-2132.mxd		A4

Materials Offloading Facility

Dredging may be required to ensure suitable barge and ferry access to the MOF. The volume of dredged material will be approximately 100,000 m^3.

Based on the currently available geotechnical information for the area, the characteristics of the material to be dredged for the MOF may be as follows:

- Soft silts and clay - 50 %;
- Sand and gravels - 40 %;
- Weak rock – 5 %; and
- Hard rock - 5 %.

Based on the assumed likely material, available water depths and the volume of material to be dredged, the dredging will be carried out using a medium sized CSD. The CSD will pump dredged material to an onshore reception lagoon and settlement pond. The most suitable location for such works will be adjacent to the MOF haul road where control of the operation and the potential beneficial reuse of the material will be possible.

The majority of the dredged material is expected to be suitable for engineering re-use, and thus will be used as fill material for the construction of the MOF and laydown area. However, due to the high content of soft clay in the material, it may not be possible to make use of all the material for engineering purposes (i.e. structural fill). This material will therefore remain in the reception lagoon where it will be stabilised and rehabilitated for use as landscaping. Alternatively it may be pumped to the proposed dredge material placement facility at Laird Point.

1.2.4 Marine Dredge Material Placement Facility

As discussed in Section 2.3.9 of the EIS, the Queensland Government and Gladstone Ports Corporation (GPC) is presently reviewing the dredged material management plan for Port Curtis to plan for the long-term dredging and dredged material disposal that may be required to provide safe and efficient access to existing and proposed port facilities in the harbour for the foreseeable future. The plan considers dredging and dredged material disposal required for industrial and port related projects currently proposed for Gladstone. The plan will include the dredging required for the Wiggins Island Coal Terminal, the LNG precinct on Curtis Island, and the further development of Fisherman's Landing. This includes the GLNG Project.

A status summary (as at October 2009) of both the Port of Gladstone Western Basin Strategic Dredging and Disposal Project and the proposed Fishermans Landing Port Expansion is provided below (refer "http://www.dip.qld.gov.au/projects/transport/harbours-and-ports.html" for further details).

Port of Gladstone Western Basin Strategic Dredging and Disposal Project

GPC is proposing to undertake the Port of Gladstone Western Basin Dredging Project (WBD project). This project accommodates the long-term dredging and dredged material disposal that is required to provide safe and efficient access to the existing and proposed Gladstone Western Basin Port (Port Curtis, from Auckland Point to The Narrows) facilities over the foreseeable future.

The WBD project comprises dredging associated with the deepening and widening of existing channels and swing basins and the creation of new channels, swing basins and berth pockets. It is proposed that dredged material be placed into reclamation areas to create a land reserve to be used to service new port facilities.

1 Introduction

The project is being undertaken in parallel with the Port of Gladstone Western Basin Master Plan which is being prepared by the Department of Infrastructure and Planning. The master plan will help government decision makers understand the scale and nature of the impacts of future industrial development in the Western Basin.

The provision of dredged channels, swing basins and berths identified in the WBD project will provide access to port facilities. These port facilities will be a key component of the import and export chain and assist in encouraging industries, including the emerging LNG industry, to develop within the Gladstone region.

An *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) referral was submitted to DEWHA in February 2009, with an Initial Advice Statement (IAS) being released for this project in March 2009. An EIS for the WBD Project was released for public comment on 15 November 2009.

Fishermans Landing Port Expansion

GPC proposes the northern expansion of the existing Fisherman's Landing facility at the Port of Gladstone through the reclamation of additional land adjacent to the existing port facility.

The reclamation will provide additional land for the construction of six wharves and provide an area for the development of transport, storage, loading and unloading facilities and will be filled using dredged material.

The reclamation will provide for the containment of dredge material from various future maintenance and capital dredging programs in the port. It is intended that the construction of the reclamation area will be staged to meet development needs. It is anticipated that at least one third of the bund wall will be constructed in a single construction program to receive capital dredging material from the proposed expansion of the Targinie Channel and Fisherman's Landing swing basin.

An IAS for the project was released in September 2005; Terms of Reference finalised in July 2006 and an EIS released for public review in March 2009.

Laird Point DMPF

If the above proposed projects are approved, the dredging and the associated dredged material placement for the GLNG Project will be undertaken by GPC in accordance with the plan provided the timing of the approval is consistent with the GLNG Project requirements.

If the project plan is not sufficiently progressed to meet the timing requirements for the approval and construction of the GLNG Project, a project-specific plan to manage the material from the dredging required for the GLNG Project has been developed. This plan is to develop a dredged material placement facility south of Laird Point on Curtis Island and is the subject of this Turtle and Dugong Management Plan. The location of the facility is shown in Figure 1-1.

It is proposed to pump the dredged material to the placement facility directly from the dredge. The pipeline between the dredge site and the facility will be in excess of 4 km and a pump booster station will be required. The pump station will be located on shore to service dredging activities and will most likely be placed at China Bay. From there, the pipeline to the dredge material placement facility will be either offshore or onshore along the Curtis Island coast as shown on Figure 1-1. The dredged material will be stored in a retention facility formed by the construction of a rock-fill bund wall across the embayment to the south of Laird Point.

The DMPF will cover an area of approximately 120 ha, and have a capacity of 10.1 million m^3 of consolidated dredged material. The DMPF will also provide some capacity for ongoing maintenance dredging.

External embankments will be constructed to a height of 22 m AHD (in four stages) which, combined with the natural contours of the land, will contain the dredge material. The dredge material will be pumped from the dredger combined with transport water, in the form of seawater, into the DMPF. The dredge material will be separated from the seawater through a series of settling ponds separated by internal bunds with adjustable weirs to allow the seawater to flow from one pond to the next. The dredged material will pass slowly through these structures, allowing the solid material (sand, silt etc) to settle out of the seawater. Following a period of controlled settlement and monitoring, the seawater will be discharged back into the marine environment.

The DMPF will be designed and managed to ensure that the quality of discharge water complies with the relevant environmental authority approval conditions.

1.2.5 Gas transmission pipeline across Port Curtis

The proposed approach is to use a clam-shell dredge to dig a trench to approximately 3 m deep, with the excavated material loaded onto a barge for transfer to the proposed DMPF. Construction techniques are likely to include either:

- Lay Barge – progressively constructing and laying the gas transmission pipeline directly on the sea floor; or
- Floatation – fabrication of the pipe string onshore and floating it into position before sinking into a trench and backfilling; or
- Cable Pull – the pipe is fabricated onshore and winched through a prepared trench.

A number of issues are involved with both construction techniques, Table 1-1 summarises the issues involved. The preferred design option for the gas transmission pipeline crossing is to trench below the seabed and to backfill with sand and/or rock. A layer of rocks may be placed over the pipe to act as additional buoyancy protection, as mechanical protection from vessels and to limit tidal scouring.

Table 1-1 Design options and issues for marine crossing gas transmission pipeline

Design Option	Summary of Issues
Laying the pipe on sea floor.	• Potential loss of gas transmission pipeline integrity due to damage from boat anchors and drifting ships. • Possible scouring – free span issue (gas transmission pipeline integrity). • Potential erosion in the surrounding area. • Limited construction periods due to tidal levels, large tidal flows and interference with boating activities.

Placing the pipe within a trench and backfilling with sand/rock.	• A wide trench width will be required to enable installation, due to sandy nature of the substrate. • Environmental disturbance of the seabed during construction. • Trench may need to be partially backfilled with rock to protect the gas transmission pipeline. • Possible scouring due to tidal currents and disturbance during construction.

1.2.6 Vessel Movements

Access to the LNG facility from the mainland will occur by barge or ferry during the construction and operational phase of the project.

Construction – Workforce Transfers

Ferries will be used to transfer construction workers from the mainland to Port Curtis during the construction of Train 1. The ferry operation may continue for the life of the GLNG Project. A number of options exist to provide a ferry service for the project. These include:

- Use of the existing Curtis Ferry Service which operates two 150 passenger capacity ferries from the Gladstone Marina. These ferries have an operating speed of 10 knots;
- Use of a high speed "fast-cat" service using ferries with a passenger capacity of 300-400 and speeds of 15-25 knots. This will require the use of ferries not currently available in Gladstone;
- Placing the buses directly onto barges which will also be used for the transfer of construction equipment. The buses could then be used to transfer the workers directly to the construction workers accommodation facility; and
- A combination of the above.

To estimate the number of ferry trips necessary for the construction phase, the following assumptions have been estimated:

- Option 2 for the Curtis Island accommodation facility (CAF) (refer to EIS Section 2, Table 2.3.8) has accommodation capacity of approximately 1,600 workers;
- Approximately 20 % of imported workers and all locally sourced workers will commute daily by ferry;
- All construction workers will work for a 10-day period followed by a 4-day rostered-off period; and
- All ferry trips are back-loaded (i.e. all ferries delivering workers to the island will bring returning workers back).

On this basis, the Train 1 construction will require 21 ferry trips per 14-day work cycle. This equates to one to two ferry trips per day (1,500 trips in total during the whole construction phase). The construction of Trains 2 and 3 will require approximately one ferry trip per day (900 trips in total during each construction phase) (refer to EIS Section 3.5 for project design specifics).

The above estimates of ferry movements have been based on the stick-built construction option. Should pre-assembled modules be used, there is unlikely to be any significant reduction in ferry movements although the capacity of the ferries could be reduced.

Construction – Barge Movements

During construction, barges will be used to transport construction materials from the mainland to Curtis Island. This will include aggregate, cement, piping, structural steel, electrical and instrumentation equipment, and machinery. The barges will be loaded at the proposed MOF on the mainland and offloaded at the China Bay MOF, Curtis Island. Whilst modular construction is the preferred plan, both stick and modular construction have been assessed.

Stick-Built

For the stick-built option, there will be approximately 2,500 barge trips for Train 1 construction. The barges will carry trucks loaded with construction materials and a capacity of four trucks per barge has been assumed. Most of the barge traffic will occur during the peak 24 month period of the construction phase. If it was evenly spread over that time it will result in three to four barge trips per day. However there will be periods of peak construction activity when the daily barge traffic will be greater than this.

For the construction of Trains 2 and 3, approximately 1,200 barge movements will be required for each train. This is because the construction of subsequent trains will required less material than the initial construction.

Pre-Assembled Modules (Likely option)

For the pre-assembled module option, there is a significant reduction in the amount of construction materials and equipment that will need to be barged from the mainland. It is estimated that the barge traffic between Fishermans Landing/Calliope River and the MOF will reduce by one third to one half of that required for the stick-built option.

The local barge traffic will be replaced by barges and heavy lift vessels coming from domestic or overseas locations delivering the pre-assembled modules. It has been estimated that there could be approximately 10 heavy lift vessels trips and 30 barges trips required to deliver the pre-assembled modules spread over three years of the construction phase. The estimated number and size of modules to be delivered is shown in Table 1-2.

Table 1-2 Estimated Number and Size of Module

Module	Number	Size (tonnes)
Process	32	700 - 2,500
Utilities	60	200 - 500
Jetty/pipe rack	25	100 - 300

The modules will be offloaded at the MOF onto self-propelled motorised transporters which will be designed to carry the heavy loads along the haul road to the construction site.

Under Australia's quarantine regulations, the GLNG Project will undertake cleaning of any imported equipment. To avoid the possibility of re-exporting due to contamination, offshore inspection by an appropriate AQIS or equivalent officer may be undertaken at the module construction site prior to shipment.

Operations

Section 3.9.2 of the EIS describes the ship movements associated with LNG export. The ships used to export the LNG will have a laden draught of up to 12.0 m, be up to 300 m in length, and could contain from 130,000 m^3 to 180,000 m^3 of LNG. LNG tankers will enter Port Curtis and proceed along the main shipping channel to the loading berth. Assuming 155,000 m^3 capacity ships, at the initial single train LNG production rate of 3 - 4 Mtpa, there will be approximately 50 ship loads exported each year, or about one ship per week. This rate will increase to 160 ships per year or about one ship every two days when the production rate increases to 10 Mtpa. Using larger ships will involve correspondingly fewer ship movements.

In the 2007/08 financial year (the latest year for which data are available), there were 1,368 ship visits to the port and the tonnage handled at Port of Gladstone was approximately 76 Mt. The Gladstone Ports Corporation's (GPC) projections of trade volumes for the 2011/12 financial year show the tonnage handled at the port increasing to approximately 104 Mt. This represents an increase of 28 Mt (37 %) over a 4 year period. Assuming a proportional increase in the number of ship movements (to an estimated 1874 ship visits), the ship movements generated by the initial LNG facility (Train 1) will represent an approximate 2.6 % increase in ship movements in the port. Ship movements from train operations will be an increase of approximately 7.8 %.

During the operational phase, the operations workforce will be accommodated on the mainland and will commute to Curtis Island daily. As discussed in Section 3.8.3.8 of the EIS it is anticipated that, maintenance and administration workers will work week days for eight hours with weekends off. The operations workers will work 12-hour shifts which could be on a two-weeks-on/two-weeks-off roster. On this basis there could be up to four ferry trips per day depending on the final roster selection. Due to the smaller workforce, the capacity of the ferries used during operations will be much less than that proposed for the construction phase.

As discussed in Section 2.3.4.2 of the EIS, following an assessment of alternative sites and based on discussions with the GPC, the preferred site for the ferry terminal on the mainland is Auckland Point however alternate areas on the mainland are presented in Appendix L. It is proposed that some upgrades will be undertaken to provide adequate ferry docking and vehicle parking facilities. On Curtis Island, the ferry terminal will be at the MOF.

1.2.7 Flaring

Table 8.12.4 of Section 8.12 (Visual Amenity) of the EIS details the visibility of major components of the LNG facility including Facing Island settlement and Curtis Island South End Township, adjacent to turtle nesting sites. The flare stack will be partially visible from the South End and Facing Island townships and the flame will be visible at these locations (refer to Table 8.12.4 of the EIS). Figure 8.12.1 of the EIS details the view shed of the gas flare stack, indicating that nesting turtles may be exposed to light glow either from the LNG facility and/or flaring activities at night time. Section 8.8.5.1 of the EIS notes that flaring will only occur during plant upset conditions or scheduled shut down and start up for maintenance. A flare pilot will remain on at all times. Section 8.8.5.2 of the EIS describes the scenarios when flaring could occur.

Upset scenarios were provided by Santos to represent the possible situations that may lead to gas release through the flares. These include the following scenarios (Table 1-3).

Table 1-3 Upset Scenarios resulting in Flaring

Situation	Description
Scheduled maintenance	Scheduled shut-down and start-up for maintenance inspection, which occurs every three years, and lasts for 3 hours.
Controlled relief	Due to blocked outlets to the propane compressors (typically approximately 15 minute duration). This scenario has not been modelled as likelihood of occurrence is rare, and may never happen during the lifetime of the facility's operation.
Emergency shut down	Rare or may never happen during the lifetime of the project.
Warm ship load out	Load-out of LNG to a ship when the ship is warm, occurring probably once in three years. It will take approximately 24 hours to cool the ship down using LNG, much of which will be boiled off and recycled back to the LNG facility for re-liquefaction.

During ship loading, gas vapours will be produced as a result of heat gain throughout the process and the venting of the displaced vapour space within the ship as it is filled. Some of these vapours will be used to displace the LNG being removed from the storage tanks during loading and the remaining vapours will be routed to boil-off gas compressors and sent back to the LNG liquefaction section for use as fuel or re-liquefaction. In this way the release of fugitive gas emissions to the atmosphere will be minimised. In the event that the vapour is produced at a higher rate than the boil off compressors can handle, the surplus vapours will be routed to a marine flare which will be located onshore at the end of the PLF.

Previous research suggests that lighting has been linked to disorientation in turtles, particularly during periods of nesting and hatching (Lutcavage *et. al*., 1996; Pendoley 1997). Hatchlings move toward bright artificial light sources in both laboratory and field settings. Studies reported by Witherington (1992) on hatchling orientation relative to spectrally controlled light sources indicated that the most disruptive wavelengths were in the range of 300–500 nanometres (nm). In contrast, light emitted from a natural gas flare has peak spectral intensity in the range from 750 to 900 nm (WAPET 1995).

As identified by Figures 8.12.1 of the EIS and Figure 2.1, the turtle nesting beach on Curtis Island lies just outside of the range of direct line of sight of the flare stack and associated flaring activities. Potential impacts to nesting turtles and hatchlings from gas flaring activities will only occur during flaring events at night time in the turtle nesting season (flatback turtles - early December to late March, with a peak in mid February). As indicated by Table 1-3, scheduled maintenance flaring is estimated to occur for a three hour period every 3 years. Emergency flaring is considered to be a rare event. It is considered that the combination of flaring at night and during turtle nesting season will be rare and extremely unlikely to coincide. However, in the event there is a direct line of sight from the stack to nesting turtle populations, or light glow from the LNG facility is considered to potentially impact nesting turtles and hatchling behaviour, or gas flaring occurs at night during turtle nesting season a turtle monitoring program will be initiated and implemented. The need to minimize light glow from the LNG facility will form part of the mitigation measures during the design phase for the project.

1.3 Regulatory Framework

Key legislation and planning policies governing marine flora and fauna and general nature conservation within the Curtis Island and Port of Gladstone area identified with regards to the LNG facility component of the GLNG Project includes:

- *Convention on the Conservation of Migratory Species of Wild Animals* (the Bonn Convention or CMS) (International);
- *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) (International);
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act);
  - Recovery Plan for Marine Turtles in Australia 2003
- *Great Barrier Reef Marine Park Act 1975* (Cth);
- *Environment Protection Act 1994* (Qld);
- *Marine Parks Act 2004* (Qld);
- *Marine Parks Regulation 2006;*
- *Nature Conservation Act 1992* (Qld) (NC Act);
- *Nature Conservation (Wildlife) Regulation* 2006 (Qld);
- *Nature Conservation (Dugong) Conservation Plan 1999* (Qld);
- *Fisheries Act 1994* (Qld):
  - *Management and protection of marine plants and other tidal fish habitats (FHMOP 001)*;
  - *Management of declared Fish Habitat Areas (FHMOP 002)*;
  - *Dredging, extraction and spoil disposal activities: Departmental procedures for provision of fisheries comments (FHMOP 004)*;
  - *Mitigation and compensation for activities and works causing marine fish habitat loss: Departmental procedures (FHMOP 005)*;
  - *Restoration notices for fish habitats - formulation and implementation: Departmental procedures (FHMOP 009)*; and
  - *Tidal fish habitats, erosion control and beach replenishment (FHMOP 010)*;
- *Fisheries Regulation 2008* (Qld)*;*
- *Vegetation Management Act 1999* (Qld);
- *Coastal Protection and Management Act 1995* (Qld);
- *Integrated Planning Act 1997* (IPA) (Qld);
- *State Coastal Management Plan – Queensland's Coastal Policy* (Qld);
- *SPP2/02 Planning and Managing Development Involving Acid Sulfate Soils*;
- *Curtis Coast Regional Coastal Management Plan*; and
- *Queensland Government Environmental Offsets Policy* (Qld).

The Department of Environment and Resource Management (DERM) has commenced a review of the *Nature Conservation (Dugong) Conservation Plan 1999.* Conservation plans are subordinate legislation under the *Queensland Nature Conservation Act 1992* (NCA) that provide a legislative and policy framework for the conservation and management of protected wildlife. The dugong conservation plan is approaching its tenth year and must be reviewed to ensure it remains current. The discussion paper has been referred to in this assessment of potential impacts to dugong in Port Curtis (DERM, 2009).

Sea Turtles

2.1 Background

The common biological characteristics of marine turtles of relevance to this management plan include:

- High fidelity to nesting sites, inter-nesting areas and foraging areas where turtles return to their natal beaches to breed;
- A limited number of available nesting sites. Beaches where nesting populations become depleted will not be 'colonised' by other turtles as turtles do not relocate to new areas;
- Hatchlings and adults are influenced by environmental cues including temperature; and
- High mortality of hatchlings and juvenile prior to reaching adulthood occurs through natural and anthropogenic causes. Levels of mortality for hatchlings has not been estimated however scientific advice suggests that one in 1000 hatchlings survive to adulthood to breed.

Key nesting habitats for marine turtles breeding within the WHA are largely known (Dobbs, 2001) and have been described in Section 2.3 of this document. Of relevance to the GLNG Project, green, loggerhead and flatback turtles are known to nest on beaches of Curtis and Facing Islands. No records of the Olive Ridley, leatherback turtles or hawksbill have been recorded within Port Curtis or nesting on beaches of Curtis and Facing Islands, although they are considered to occur within the region (Table 2-1).

2.2 Conservation Status

Marine turtles are recognised internationally as species of conservation concern and are listed in the 2000 IUCN (World Conservation Union) Red List of Threatened Animals. All marine turtle species occurring in Australian waters are listed under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). In addition, all marine turtles occurring in the Indo-Pacific region are a priority for conservation under the *Convention on the Conservation of Migratory Species of Wild Animals* (CMS) also known as the Bonn Convention. Australia recognises these agreements Australian Government's *Environment Protection and Biodiversity Conservation Act* 1999.

Six of the seven species of marine turtles occur in Australian waters; and the coastal region of north Queensland supports five of these species. All species of marine turtles are protected under Queensland's *Nature Conservation Act* 1992 and the Australian Government's *Environment Protection and Biodiversity Conservation Act* 1999. The loggerhead (*Caretta caretta)* and olive ridley (*Lepidochelys olivacea*) turtle are listed as endangered under the *EPBC Act* 1999 and the green (*Chelonia mydas*), hawksbill (*Eremochelys imbricata*) and flatback (*Natator depressus*) turtles are listed as *vulnerable* (Table 2-1).

Table 2-1 Conservation Status of Marine Turtles in Port Curtis

Species	EPBC Act Status	NC Act Status	Bonn[1]	CITES[2]	Notes
Caretta caretta *Loggerhead Turtle*	Endangered	Endangered	Appendix I & II	Appendix I	Occasional breeding in area
Chelonia mydas *Green Turtle*	Vulnerable	Vulnerable	Appendix I & II	Appendix I	Occasional breeding in area
Dermochelys coriacea *Leatherback Turtle*	Vulnerable	Endangered	Appendix I & II	Appendix I	Species known to occur within area
Eretmochelys imbricate *Hawksbill Turtle*	Vulnerable	Vulnerable	Appendix I & II	Appendix I	Species known to occur within area

Lepidochelys olivacea *Olive Ridley*	Endangered	Endangered	Appendix I & II	Appendix I	Species or species habitat may occur within area
Natator depressus *Flatback Turtle*	Vulnerable	Vulnerable	Appendix I & II	Appendix I	Breeding known to occur within area

[1.]Convention for the Conservation of Migratory Species of Wild Animals (Bonn)

[2.]Convention for International Trade in Endangered Species (CITES)

2.3 Sea Turtle Ecology

The three species of marine turtles known to nest within the southern GBRWHA are the loggerhead turtle, green turtle and flatback turtle. The leatherback turtle had rookeries in southern Queensland up until the early 1990s (Hamann *et al.,* 2006). All known nesting sites throughout the region have been identified in the literature and through personal communication with experts (loggerhead: Limpus *et al.,* 1984a; McLachlan *et al.,* 2006; green: Limpus *et al.,* 1984a; Limpus *et al.,* 2003; flatback: Limpus *et al.,* 1989*,* 2002; hawksbill: Limpus *et al.,* 2008; leatherback: Hamann *et al.,* 2006).

Present understanding of the biological characteristics of marine turtles are based on the life cycle of the green and loggerhead turtles although specific characteristics differ between species. Male and female turtles migrate from foraging areas 100-1000's km away to a nesting location considered to be their natal place of birth (Dobbs, 2001). Female turtles lay multiple clutches of eggs each season (2-7 clutches) each clutch containing 50-200 eggs (Dodd, 2001). Females return to their foraging after the nesting season and only nest every 2-8 years (Dobbs, 2001). Hatchlings usually emerge at night following an incubation period of around 60 days (Dobbs, 2001) and orient towards the brightest direction to find the sea using the topographic line of sight as a point of reference (Dobbs, 2001).

A combination of cues including wave direction, current and magnetic fields are used to orient the hatchlings towards deeper waters (Dobbs, 2001). It is believed that crossing and swimming away from the beach imprints the hatchlings with cues for future returns to their natal birth place when they are preparing to breed (Dobbs, 2001). Once offshore hatchlings possible enter regions of convergent water systems where they associate with floating seaweed mats that are driven by surface water currents (Dobbs, 2001). Young turtles then migrate to inshore foraging areas after their developmental years between 5 to 20 years (Dobbs, 2001; Limpus, 1992).

There are several well-documented anthropogenic threats to marine turtles and their habitats in the GBRWHA such as coastal development, habitat loss, boat strike, indigenous hunting and fisheries interactions (Limpus and Couper, 1994c; Limpus and Miller, 1994a; Robins, 1995; Robins, 2002; Limpus *et al.,* 2003; Hazel and Gyuris, 2006). Among them, the pressure from commercial fisheries such as netting and trawling on both the turtles and their important habitats was regarded by the Great Barrier Reef Marine Park Authority (GBRMPA) as the two biggest concerns for marine turtles (Dobbs 2007). Various legislative Acts and zoning plans within the GBRWHA manage both of these commercial fisheries.

A brief summary of the ecology of the six sea turtle species which are potentially present in the area are presented below.

Loggerhead turtles (*Caretta caretta*) feed mostly on shellfish, crabs, sea urchins and jellyfish (Limpus, 2004). Significant nesting areas in Australia occur on the southern Great Barrier Reef and adjacent mainland coastal areas, including Bundaberg, Wreck Island, Erskine Island, Tryon Island, Wreck Rock beach and Pryce Cay and in Western Australia including the Murion Islands and further south near Shark Bay. Females originally tagged near the south east Queensland rookeries have been recaptured in Indonesia, Papua New Guinea, the Solomon Islands, New Caledonia, the Northern Territory, New South Wales and other parts of Queensland. The eastern Queensland loggerhead population is genetically distinct from loggerhead turtles breeding in Western Australia (Dobbs, 2001).

In the south-west Pacific, the only major breeding of loggerhead turtles occurs in Queensland mainly on islands offshore of southern Queensland (Capricorn-Bunker Islands; Sandy Cape; Swains Complex) and on the mainland around Bundaberg (Elliot River to Round Hill Head) (Limpus, 1993; Limpus and Reimer, 1994b; Dobbs, 2001). Numbers of breeding loggerheads have declined in Queensland from an estimated total breeding population of 1,000 females in 1989 in the Mon Repos area to approximately 300 female loggerhead turtles nesting annually in the region a decade on (Limpus and Reimer, 1994b; Dobbs, 2001). This decline has been attributed to intense fox predation of eggs along the Bundaberg coast and incidental catch of immature and adult turtles in commercial fisheries (Limpus and Reimer, 1994b; Dobbs, 2001).

Occasional nesting has been reported to occur on the ocean side of southern Curtis Island and Facing Island (Limpus, 1999) and have been recorded within the outer harbour of Port Curtis and moving north through The Narrows (QDEH, 1994). In south eastern Queensland mating and loggerhead turtles nesting behaviour has been observed to commence around late October, reaching a peak from November to early December (Limpus and Reimer, 1994b). Loggerhead turtles finish nesting in late February or early March. Hatchlings emerge from nests between late December to April with most turtle eggs hatching between February and early March.

The observations of occasional nesting behaviour of this species may be explained by the decline in the breeding population and subsequent decline in the number of hatchlings surviving to breeding age. However, because no interbreeding occurs between genetically different breeding units, repopulation of nesting beaches would be unlikely (Bowen *et al.,* 1994).

Green turtles (*Chelonia mydas*) occur in seaweed-rich coral reefs and inshore seagrass pastures in tropical and subtropical areas of the Indo-Pacific region (Limpus, 2004). Green turtles feed on small marine animals when they are young, but once they move to their adult foraging grounds green turtles mainly eat seagrass and seaweed (algae). They also feed on mangrove fruit, jellyfish and sponges.

Limpus (2004) reports there are four major green turtle nesting areas in Australia:

1. The northern Great Barrier Reef has five major rookeries, including Raine Island and nearby cays, and Bramble Cay in the Torres Strait.
2. The south-eastern Gulf of Carpentaria has three major rookeries at Bountiful, Pisonia and Rocky Islands. Large numbers of greens occur in suitable feeding areas along the south-west coast of the Gulf of Carpentaria, adjacent to the Sir Edward Pellew Islands.
3. The north-west shelf in Western Australia has widely spread, major rookeries, including the Lacepede Islands, sites north of Broome, and Barrow and the Monte Bello Islands further south. Small numbers also nest on the National Nature Reserves in the Indian Ocean. Green turtles nesting along the WA coast migrate from feeding grounds in Indonesia, Queensland, Northern Territory and Western Australia.
4. Queensland has three distinct genetic breeding stock of green turtles with very little interbreeding occurring between these distinct populations (Dobbs, 2001). The southern Great Barrier Reef has

13 major rookeries, including North West Island, Wreck Island, Hoskyn Island, Heron Island and the Coral Sea cays.

Limpus (2007) reports that the southern GBR stock of green turtles is large by global standards and that, overall this population is not showing signs of decreasing numbers of breeding females at the nesting beaches over the past four decades. Limpus (1997) estimated a breeding population of 8,000 female green turtles in the southern GBR around Capricorn/Bunker group of islands and in the Coral Sea Islands Territory. Nesting occurs between late November and January in southern Queensland. Occasional nesting of green turtles occurs on the ocean side of southern Curtis Island and Facing Island (Limpus, 1999).

Flatback turtles (*Natator depressus*) are only known to breed in Australia and is one of two species without a global distribution. They feed in the northern coastal regions of Australia, extending as far south as the Tropic of Capricorn. Their feeding grounds also extend to the Indonesian archipelago and the Papua New Guinea coast (DEWHA, 2003). Flatback turtles have a preference for shallow, soft-bottomed sea bed habitats away from reefs. The Australian flatback turtle prefers shallow, turbid, inshore waters and bays where they feed on sea cucumbers and other holothurians, as well as jellyfish, prawns, molluscs, bryzoans, and other invertebrates (Ripple, 1996). Juvenile flatback turtles eat shellfish, squid and jellyfish. Adult flatback turtles are known to forage soft-bottom habitats and eat cuttlefish, hydroids, soft corals, crinoids, shellfish and jellyfish. They feed mainly inshore of the outer Great Barrier Reef from Hervey Bay to Torres Strait, Gulf of Carpentaria, North West Shelf, Arafura Sea and the Gulf of Papua.

Flatback turtles nest on inshore islands and the mainland from Mon Repos in the south to around Mackay in the north. Other major nesting areas occur in the Kimberley region of Western Australia and extend to the Torres Strait. The inner shelf area of the southern Great Barrier Reef includes four major rookeries on Peak, Wild Duck, Avoid and Curtis Islands (Dobbs, 2001). Although flatback turtles are also found within the PNG and Indonesian archipelago they are only known to breed in Australia with greatest concentration of breeding individuals in the southern GBR around Peak, Wild Duck, Avoid, Curtis and Facing Islands (Dobbs, 2001). Genetic studies on flatback turtles indicates that the eastern Queensland populations of nesting turtles are distinct from those found in the Gulf of Carpentaria and Torres Strait, Northern Territory and Western Australia (Dobbs, 2001).

Low densities of nesting flatback turtles occurs on mainland beaches and island offshore of Gladstone. The largest known nesting site in Queensland is Crab Island, outside of the WHA. Nesting activity reaches a peak between late November and early December, and ceases by late January. Hatchlings emerge from nests from late December until about late March, with most hatching during February.

Leatherback turtles (*Dermochely coriacea*) occur in tropical and temperate waters of Australia. Large numbers of leatherback turtles feed off the south Queensland and New South Wales coasts and off Western Australia's coast, south of Geraldton. They are less abundant in the tropical waters of the northern Australian continental shelf. Most leatherback turtles living in Australian waters migrate to breed in neighbouring countries, particularly in Java and along the northern coast of West Papua, Papua New Guinea and the Solomon Islands.

The diet of Leatherback hatchlings and juveniles is not known. Adult Leatherbacks feed on jellyfish, salps and squid on the ocean surface and down to depths of 200 m. There are records of intermittent nesting on beaches between Rockhampton and Fraser Island, but no records of its occurrence in Port Curtis.

No large rookeries have been recorded in Australia. Scattered nesting occurs along the south Queensland coast from Bundaberg to Round Hill Head and along the coast of Arnhem Land from Coburg Peninsula to Maningrida, including Croker Island.

Hawksbill turtles (*Eretmochelys imbricate*) typically occur in tidal and sub-tidal coral and rocky reef habitats throughout tropical waters, extending into warm temperate areas as far south as northern New South Wales (Limpus, 2004). In Australia the main feeding areas extend along the east coast, including the Great Barrier Reef. Other feeding areas include Torres Strait and the archipelagos of the Northern Territory and Western Australia, possibly as far south as Shark Bay or beyond.

Sponges make up a major part of the diet of hawksbill turtles, although they also feed on seagrasses, algae, soft corals and shellfish. Along the Great Barrier Reef, hawksbills nest in low numbers from just north of Princess Charlotte Bay to Torres Strait. Nesting also occurs in the Northern Territory and Western Australia.

Two major breeding areas occur in Australia: Northern Great Barrier Reef, Torres Strait and Arnhem Land have several significant rookeries including: Milman, Johnson, Bouydong, Bird and Piper Islands in the Northern GBR; Aukane, Kabikane, Mimi, Bet, Sassie and Lacey Islands in Torres Strait; and Hawk, North East and Truant Islands in north east Arnhem Land. The North West shelf has several significant rookeries including Rosemary and Varanus Islands. Although hawksbills breed throughout the year, the peak nesting period in the Torres Strait and Great Barrier Reef region occurs between January and April. In Arnhem Land, nesting peaks between July and September. Major nesting of hawksbill turtles in Australia occurs at Varanus Island and Rosemary Island in Western Australia (Pendoley, 2005), and in the northern Great Barrier Reef and Torres Strait (Dobbs *et al*., 1999; Limpus *et al*., 1989), Queensland.

Hawksbill hatchlings feed on very small (planktonic) plants and animals floating in the ocean. When they grow to between 30 and 40 cm (curved carapace length) they begin feeding among coral and rocky reef habitats on the sea floor. Juvenile and adults hawksbill turtles eat a variety of marine plants and animals, particularly algae, seagrass, sponges and shellfish (SPRAT Database).

Olive Ridley turtles (*Lepidochelys olivacea*) have a worldwide tropical and subtropical distribution, including northern Australia. Olive Ridley turtles occur in shallow, protected waters, especially in soft bottomed habitats. In Australia, they occur along the coast from southern Queensland and the Great Barrier Reef, northwards to Torres Strait, the Gulf of Papua, Gulf of Carpentaria, Arafura Sea and Joseph Bonaparte Gulf in Western Australia.

The Olive Ridley turtle is carnivorous, feeding mostly on shellfish and small crabs. No large rookeries of olive ridleys have been recorded in Australia. An estimate of the nesting population for Australia is 500-1000 females annually, with most nesting in north-west Arnhem Land (Limpus, 1995a). Olive Ridley turtles nest all year round, although most nesting occurs during the dry season from April to November. Hatchlings emerge from the nests about two months after laying.

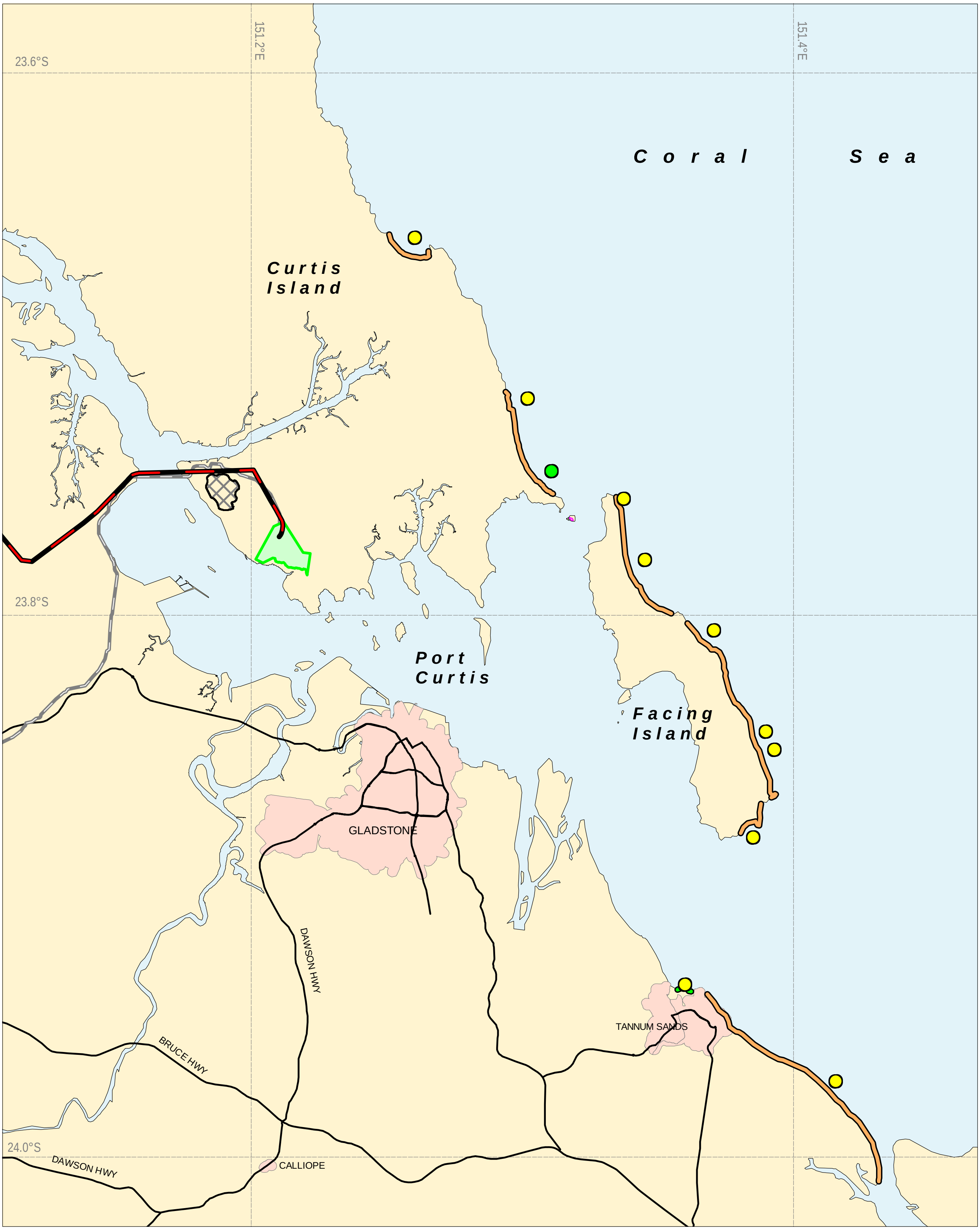
This species is classed as the most abundant of the sea turtles. However, in Malaysia the nesting population has declined to 20 % in recent years. Many of the large Arribadas such as in Surinam have been reduced to several hundred individuals (Limpus, 1995b) (SPRAT Database).

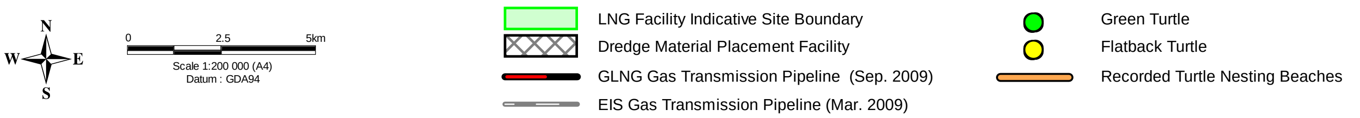
2.4 Sea Turtles in the Port Curtis Area

Loggerhead turtles (*Caretta caretta*) and green turtles (*Chelonia mydas*) have occasionally nested on the ocean side of southern Curtis Island and Facing Island (Limpus, 1999). Several green turtles were seen by researchers during the field surveys conducted in 2008 and 2009 for the Santos GLNG EIS and it has been reported that The Narrows and the Calliope River mouth are major foraging areas (Connell Hatch 2006). According to a study conducted by QDEH and GPA (1994), the loggerhead turtle (*Caretta caretta*) and flatback turtle (*Natator depressus*) utilise habitats in the outer harbour and occasionally move northward through Port Curtis into The Narrows.

The beaches on the ocean side of southern Curtis Island and Facing Island support an important intermediate breeding population of flatback turtles (*Natator depressus*) (Limpus, 2007). Flatback turtle nesting commences in mid October, reaches a peak in late November – early December and ceases by about late January. Hatchlings emerge from nests between early December and late March, with a peak in February (Limpus, 2007). Flatback turtles are known to occur within the outer Gladstone harbour and to move north through The Narrows (QDEH 1994). The flatback turtle population utilising these beaches for nesting has remained consistent over 35 years of monitoring with approximately 50 females nesting annually (Limpus *et al*., 2006). There are no recognised nesting beaches inside Port Curtis, with the closest sites being used by flatback (and occasionally green) turtles at North Cliff Beach (Facing Island) and the main beach at South End (Curtis Island), where annual numbers have been estimated at 25-50 per beach (QDEH & GPA, 1994) .

Figure 2-1 shows the locations where turtle nesting has been recorded during previous studies (DERM, 2008).





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Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY DUGONG AND TURTLE MANAGEMENT PLAN	**TURTLES NESTING SITES**
	Drawn: CA · Approved: JB · Date: 03-11-2009	Figure: **2.1** · Rev:C
	Job No: **4262 6440** /6220 · File No: 42626440-g-2114c.wor	A4

Dugongs

3.1 Conservation Status

Dugong (*Dugong dugon*) is listed as Vulnerable to Extinction at a global scale by the IUCN and is also listed on Appendix I of CITES and on Appendix II of the CMS or Bonn Convention. Australia is signatory to both the IUCN and the CMS Conventions and recognises these agreements under the Australian Government's *Environment Protection and Biodiversity Conservation Act* 1999 as a 'listed marine' and a 'listed migratory' species. The Commonwealth government has now proposed that a National Wildlife Conservation Plan for Dugongs in Australia be developed to co-ordinate actions between States, the Northern territory and the Australian Government necessary to support the conservation and management of dugongs (DERM Marine Mammal Conservation Plan Review Discussion Paper, 2009). The recovery plan addresses habitat degradation, incidental mortality from fishing, boating traffic, Indigenous hunting, education, research and monitoring.

Dugongs are protected under Queensland's *Nature Conservation Act 1992 (Qld)* (NC Act), and listed as 'vulnerable wildlife' under Schedule 3 of the *Nature Conservation (Wildlife) Regulation 2006 (Qld),* noting that *the conservation of the habitat of vulnerable wildlife is critical to ensuring the survival of the wildlife*. Under this legislation recovery or conservation plans may be initiated as a priority and EIS procedures may be monitored and review in terms of addressing the adequacy of impact assessment and mitigation measures in addressing potential impacts from proposed development.

Dugong (*Dugong dugon*) are listed as Vulnerable in Queensland waters under the *NC Act* (Qld). Conservation of the dugong is also provided for in the *Marine Parks Act 2004 (Qld)* and *Marine Parks Regulation 2006 (Qld).* The *Nature Conservation (Dugong) Conservation Plan 1999 (Qld)* provides a statutory framework for the take and rescue of dugong in Queensland waters. Implementation of a recovery plan is aimed at the protection and recovery of dugong populations in nominated Dugong Protection Areas (DPAs).

The system of dugong protection areas (DPAs) was established under the *Fisheries Regulation 2008* to protect dugongs in the southern Great Barrier Reef and Hervey Bay regions, aimed at reducing the decline of dugong numbers from entanglement in fishing nets within prime dugong habitat areas. The Port of Gladstone region is wholly within the Rodds Bay Dugong Protection Area B (Figure 3-1). The Rodds Bay Dugong Protection Area (B) is declared under the *Fisheries Act 1994 (Qld)* and regulated under the *Fisheries Regulation 2008 (Qld)*, restricting the use of commercial fishing nets in the Port of Gladstone from The Narrows entrance to Rodds Peninsula. No further provisions are prescribed under this legislation. These restrictions were also legislated in the *NC Act 1992* (Qld).

The Great Barrier Reef Marine Park (GBRMP) region supports globally significant populations of the dugong. Special Management Areas for protection of dugong were declared under the *Great Barrier Reef Marine Park Regulations 1982 (Cwth)* and the *Great Barrier Reef Marine Park Zoning Plan 2003 (Cwth).*

The GLNG Project is within a Species Conservation (Dugong Protection) Special Management Area (Dugong Protection Area B).

3.2 Dugong Ecology

Dugongs are the only marine mammal that are herbivorous and are the only surviving species in the Family Dugonidae (GBRMPA, 2007). Dugongs have a high conservation value as well as cultural, social and spiritual significance for Indigenous Australians and are considered an indicator of ecosystem health for coastal marine habitats, particularly seagrass systems. The range of dugong extends from east Africa to Vanuatu between latitudes of about 27^0 north and south of the equator. Numbers of dugong have declined in most countries and territories where they are found such that relict populations remain separated by large distances (Marsh *et. al.,* 2002). Significant populations of dugongs inhabit the shallow, protected inshore waters of the Great Barrier Reef World Heritage Area (GBRWHA; Marsh *et al.,* 2002) and were an explicit reason for the region's World Heritage listing (GBRMPA, 1981).

Dugong are long-lived with the oldest individual age estimated at 73 years (Marsh, 1980; Marsh, 1985; Marsh, 1995) and they are known to reach sexual maturity at 6 to 17 years for females with long calving intervals of 2.4 to 7 years (Marsh, 1995; Kwan, 2002; Marsh and Kwan, 2008) resulting in a low rate of maximum population increase of less than 5 % per year. Mean population trends are sensitive to survival probability of adults; therefore dugong populations are vulnerable to even small levels of human induced mortality (Marsh, 1995).

Dugongs are specialist feeders on seagrass, and have distinct preferences, which seem to be based on the nutritional quality of the seagrass (Lanyon, 1991; Preen, 1993), especially the genera *Halophila* and *Halodule* (EPA and QPWS, 1999). Studies indicate that dugong move from shallow inshore summer feeding areas to deeper water in the winter where temperatures remain higher (Anderson, 1985; Marsh *et al* 1994; Gales et al 2004; Holley *et al* 2006). Some local movements of dugong also coincide with tidal movements in areas where dugongs are dependant on seagrass growing in intertidal and shallow sub-tidal areas (Heinsohn *et al.,* 1977; Anderson and Birtles, 1978; Marsh and Rathbun, 1990; Sheppard *et al.*, 2006).

Dugong mothers suckle their calves for 14 to 18 months and young dugongs forage on seagrass soon after birth while still suckling milk from their mother (Smyth, 2006). Hodgson's PhD research indicated that mothers spend significantly more time feeding and surfacing and less time travelling with their calves rendering them most vulnerable to boat strike (Hodgson, 2004). According to this research, vessel speed is considered the main factor affecting the risk of boat strikes.

It is hypothesised that delay in onset of breeding may be linked to the availability of seagrass, and similar to other mammals dugong may delay breeding when in short supply of food (Smyth, 2006). This effect is multiplied when habitat quality is reduced and studies indicate that dugong fecundity is also reduced (Marsh and Kwan, 2008). A previous case of seagrass die back resulted in deaths of dugongs in Hervey Bay in 1992 (Preen *et. al.*, 1995). It was hypothesised that increase sedimentation on adjacent seagrass beds resulting from terrestrial run-off and flooding of the Mary River caused mass die-back of seagrass meadows in Hervey Bay (Preen *et. al.*, 1995). Reductions in water quality that included low salinity, sedimentation, increased turbidity (and reduced light availability) and nutrient stress was considered the causes of the extensive mortality of seagrass meadows in the area. Reduced light availability was considered the most significant cause for decline of seagrass meadows and the decrease in depth distribution resulting from either increased levels of phytoplankton (with increased nutrient levels) or by increased loads of suspended sediment (GBRMPA Report 66). High numbers of dugong mortality were recorded in the area probably due to a lack of food supply.

Aerial surveys have been conducted regularly since the 1980's, however the surveys have been less useful in detecting long-term trends in abundance or for setting sustainable catch quotas because of difficulties in: (1) estimating absolute population size especially in the absence of defined stock boundaries, (2) separating changes in distribution from changes in population size, and (3) stabilising the corrections for availability bias which varies during the day due to diurnal changes in dugong behaviour. It is extremely likely that the surveys still underestimate dugong abundance despite the attempts to correct for perception and availability biases (Marsh et al., 2007). Anecdotal information and dugong by-catch in shark control nets indicate that populations of dugongs along the Queensland coast have declined since the 1960's indicated by declining catch rates of dugong (Marsh *et. al.,* 2005). If catch rates are a reliable index of population estimates then the dugong population numbers found in the 1990's were 3.1 % of the population estimated along the urban coast of Queensland in the 1960's (Marsh *et. al.,* 2005).

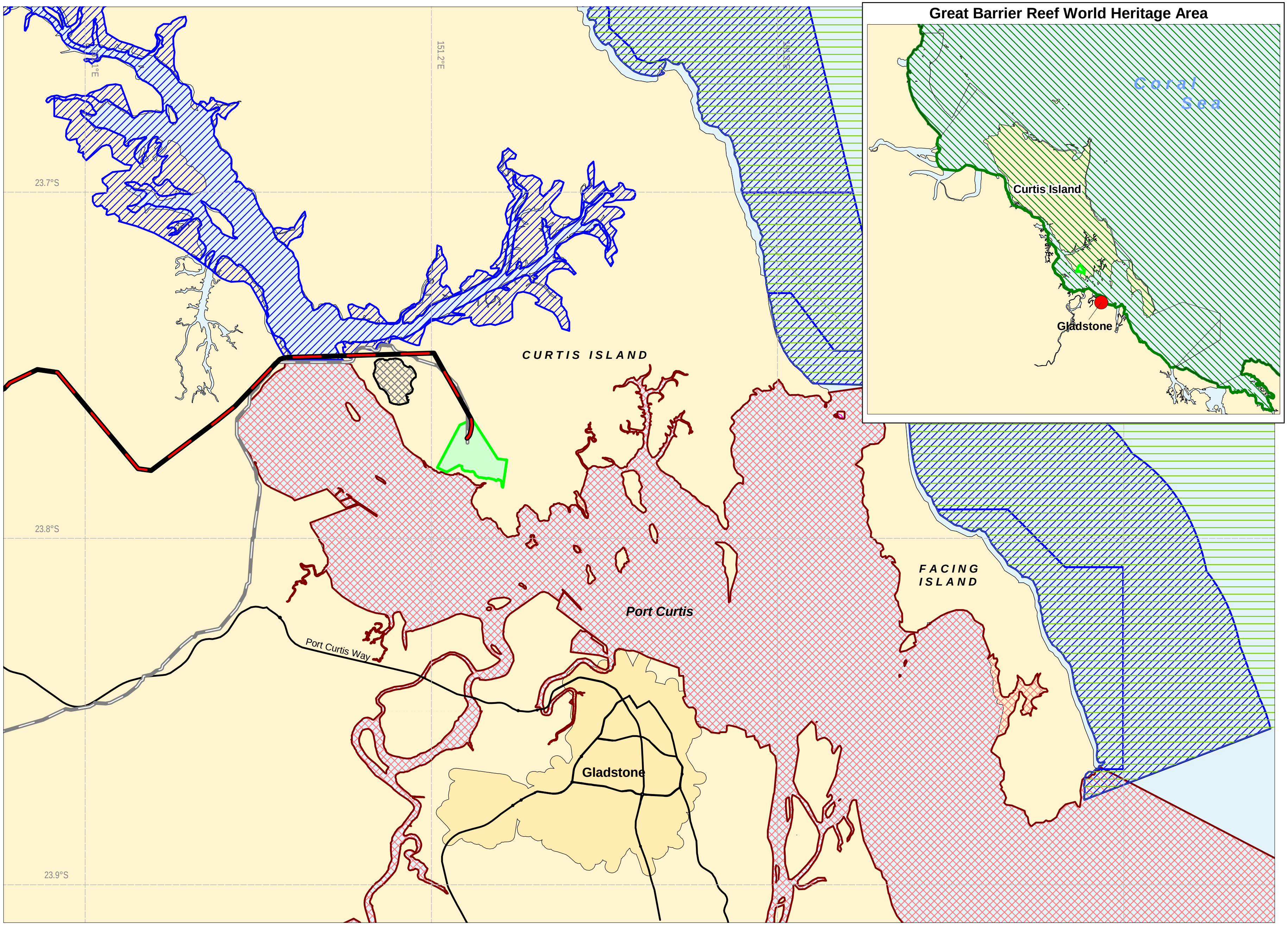
3.3 Dugongs in the Port Curtis Area

Marsh and Lawler (2006) estimated that dugong populations fluctuate in the Rodds Bay/Port Curtis area due to finer scale movements between bays.

A marine wildlife stranding and mortality database has been maintained by the Queensland Parks and Wildlife Service (QPWS), DERM since 1996 to record interactions with dugongs within Queensland, including Port Curtis. Some of these interactions have been attributed to impacts from fishing activities and boat strike, determined by visible markings that were reported at the time (Greenland and Limpus, 2005).

Evidence of dugong feeding activity has been observed on the majority of intertidal seagrass meadows surveyed in Port Curtis during the 2007 DPI&F long term monitoring program (Chartrand *et al*., 2009). During this program the highest density of dugong feeding trails was observed at the *Zostera capricorni* / *Halophila ovalis* meadow at Wiggins Island with feeding trails recorded at 69 % of sampling sites within Port Curtis. Dugong feeding trails were also recorded at Pelican Banks and the intertidal meadows to the north and south of Fisherman's Landing (Chartrand *et al*., 2009) (Figure 3-2). Field surveys conducted on Curtis Island in April 2008 recorded a mother and calf dugong pair sighted in the area of Pelican Banks on the lee side of Facing Island (refer to Figure 3-1).

Recent aerial surveys conducted by GHD (2009) for the Western Basin Dredging and Disposal EIS support similar findings identified in the dugong spatial model by Grech and Marsh (2007) whereby most of the sightings were in the southern section of Rodds Bay. Port Curtis was classified as being of Low to Medium Conservation Value by Grech and Marsh's (2007) spatial modelling. Eighty-one dugong were recorded during the GHD (2009) aerial and boat-based surveys.



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- Great Barrier Reef World Heritage Area
- Great Barrier Reef Coast Marine Park (QLD)
- Great Barrier Reef Marine Park (CTH)
- Dugong Protected Area
- LNG Facility Indicative Site Boundary
- Dredge Material Placement Facility
- GLNG Gas Transmission Pipeline (Sep. 2009)
- EIS Gas Transmission Pipeline (Mar. 2009)

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Client

Project
GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT
SUPPLEMENT
MARINE ECOLOGY
DUGONG AND TURTLE MANAGEMENT PLAN

Drawn: CA | Approved: JB | Date: 22-10-2009

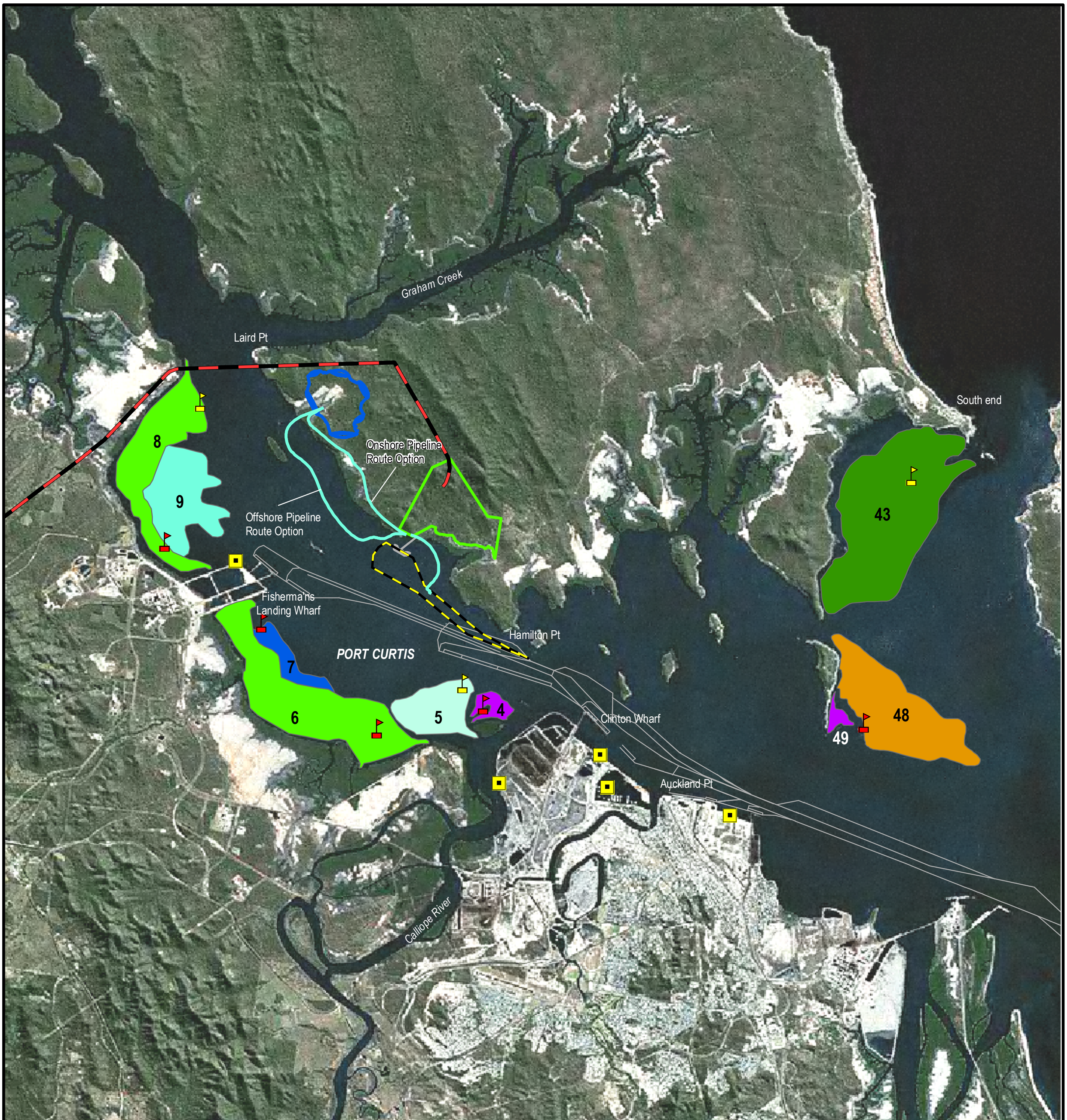
Job No: 4262 6220/6220 | File No: 42626440-g-2115.wor

Title
MARINE PROTECTED AREAS

Figure: 3.1

Rev: B

A4



DATA LOGGERS

- Light, Turbidty & Temp
- Temp Only

SEAGRASS

- Light Halodule uninervis (wide) with mixed species - Aggregated Patches
- Light Halophilia decipiens - Continuos Cover
- Light Halophilia ovalis with mixed species - Isolated Patches
- Light Zostera capricorni - Aggregated Patches
- Light Zostera capricorni with mixed species - Isolated Patches
- Moderate Halophilia decipiens with mixed species - Aggregated Patches
- Moderate Zostera capricomi - Continuous cover

- Mainland Marine Facilities
- GLNG Gas Transmission Pipeline (Sep. 2009)
- Dredge Delivery Line
- Existing Channels
- Proposed Dredging Channel
- Dredge Material Placement Facility
- LNG Facility Indicative Site Boundary

N W E S

Kilometers
0 0.5 1 2 3 4

Scale 1:125 000 (A4)
Datum : GDA 94

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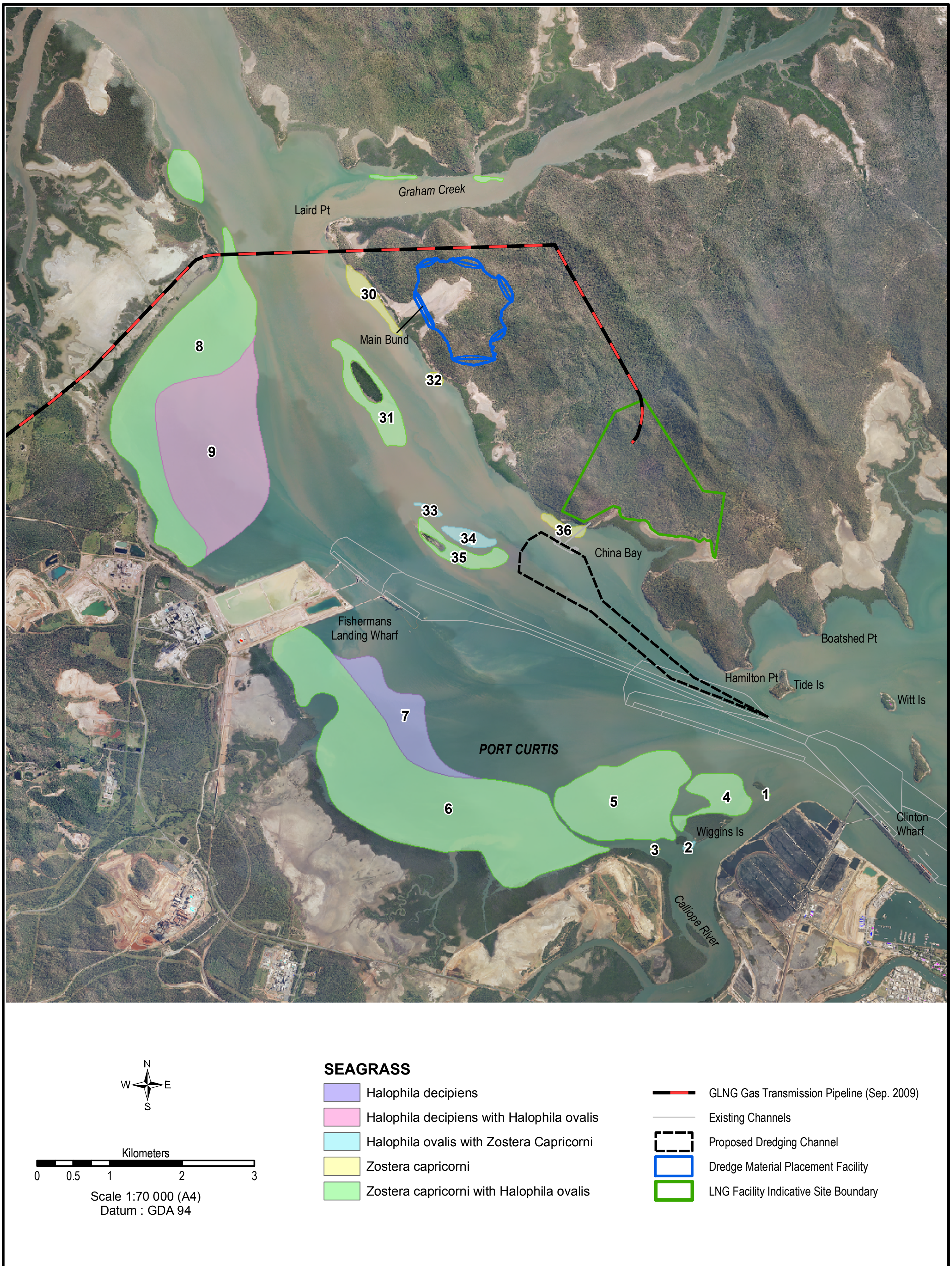
Client

URS

GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT
MARINE MAINLAND FACILITIES ASSESSMENT

SEAGRASS MEADOWS IN PORT CURTIS CHARTRAND ET AL 2009

Drawn: MG	Approved: KK	Date: 13-11-2009	Figure: 3-2	Rev. B
Job No.: 4262 6440	File No.: 42626440-g-2143.mxd			A4



Client	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY DUGONG AND TURTLE MANAGEMENT PLAN		**DISTRIBUTION OF SEAGRASS WITHIN PORT CURTIS REPRODUCED FROM RASHEED ET AL (2003)**
URS	Drawn: MG	Approved: JL	Date: 13-11-2009
	Job No.: **4262 6440**	File No.: 42626440-g-2144.mxd	Figure: **3-3** Rev. A A4

Potential Impacts, Actions and Strategies

4.1 Potential Impacts

In summary, potential for direct impacts to turtles and dugong may occur from:

- Boat strike from vessel movements and general operations;
- Capture by suction pressure associated with the dredge head (within approximately 1 m);
- Damage/mortality to individual animals from direct contact related to construction activities;
- Ingestion of or entanglement in rubbish;
- Disturbance and displacement from noise and vibration; and
- Decrease in water quality from dredging or construction activities.

Indirect impacts to turtles and dugong may occur through:

- Removal and smothering of seagrasses from increased sedimentation;
- Degradation of habitats from anthropogenic use;
- Lighting;
- Reduced water quality;
- Noise and vibration impacts from construction below the high tide mark and ongoing operational activities; and
- Increased risk to dugong and turtle through ingestion of waste and rubbish and smothering of benthic habitat.

The Hawksbill, Olive Ridley and Leatherback turtle have not been observed within Port Curtis. This section is therefore limited to discussion on the potential impacts to loggerhead, green and flatback turtles and dugong.

4.1.1 Capital and maintenance dredging

Capital dredging for the navigation channel, PLF, MOF and berthing pockets will have direct impacts to the marine environment and hance may have marine fauna such as turtles and dugong. Ongoing maintenance dredging may also result in potential impacts to the marine environment and marine fauna. Potential impacts from dredging activities are likely to be the most significant cause of both short and long term habitat degradation in the marine environment within the location of the project. Interactions between marine fauna and the dredger are also possible. Results from sediment plume modelling and desktop research have been extrapolated to predict possible impacts to dugongs and turtles from increased TSS and light attenuation. Sound pressure levels produced underwater from construction and operation of the LNG facility and associated infrastructure are not predicted to have any long term detrimental effects on marine fauna within the area (refer Appendix U2 of the EIS). Short term avoidance by turtles and dugong of the areas surrounding pile driving or dredge activities is expected.

Changes in the behaviour of dugong and turtle may occur resulting from the following construction and operational potential impacts:

- Pile driving, dredging and general construction below the high tide mark will increase sedimentation and turbidity within Port Curtis resulting in temporary declines in water quality, habitat degradation and potential displacement of marine fauna in the local area;
- Although turtles do not have external ears they detect sound through bone conducted vibration with the skull and the shell receiving surfaces (DEWHA, 2003). Turtles and dugong may exhibit a startle

response from unexpected noise and vibration (refer Underwater Noise Impact Assessment, Appendix U2 of the EIS,); and

- Dredging activities may result in interactions with turtles and dugong by the dredge head.

Underwater noise from dredging operations is up to 5 dB higher than normal shipping activities. However the fact that dredging remains at the dredge sight means that sound sensitive species would avoid the dredge, rather than requiring to vacate the area to avoid interactions with oncoming vessels. This and other issues are discussed in Appendix U2 of the EIS.

A study of interactions between dugongs and seagrasses in Moreton Bay found that dugongs favoured areas of low biomass, dominated by *Halophila* species, and that almost all of the areas avoided were dominated by *Zostera capricorni.* Further, the mean biomass where dugongs were sighted and where tracking fixes occurred was 21.2 g dw m^{-2} and 15.3 g dw m^2, respectively (Preen 1992). Seagrass monitoring studies conducted in Port Curtis (Chartrand *et al.,* 2009) reported dugong feeding activity on the majority (69%) of intertidal seagrass meadows surveyed. The highest density of dugong feeding trails was observed at the light *Zostera capricorni* meadow at Wiggins Island (west) (meadow 5) (Chartrand *et al.,* 2009). Dugong feeding trails were also observed at Quoin Island meadows (meadow 48 & 49), Wiggins Island (meadow 4), Pelican Banks (meadow 43), South Trees (meadow 58) and across the intertidal meadows to the north and south of Fisherman's Landing (meadow 6 & 8) (refer Figure 3.2 Attachment F5 Turtle and Dugong Management Plan).

The highly patchy and ephemeral nature of seagrass meadows adjacent to Laird Point that were observed in 2002 suggest that minimal potential impacts are likely to marine resources from construction of the pipeline. When this information is considered in the context of the "at risk" seagrass meadows, meadows 36, 124 and 125 would be expected to be totally avoided by dugongs, communities 31 and 35 are unlikely to be utilised, and communities 33 and 34 have such low biomass that it would be unlikely that they would provide important feeding grounds for dugongs.

Seagrass meadows found at Friend Point may incur increased sediment from elevated TSS levels, however it is anticipated to be short term and highly localised.

Potential Impacts to seagrass from dredging activities

According to the most recent monitoring studies conducted in 2007 by Chartrand *et. al.* (2009) significant meadows of *Halophila* and *Halodule* within Port Curtis are located in the subtidal areas north and south of Fisherman's Landing (meadow 9 & 7), adjacent to Wiggins Island (meadow 4) and on the southern side of Quoin Island (48 & 49) (Figure 3-2). Light *Zostera capricorni* seagrass meadows are found north and south of Fisherman's Landing (meadow 8 & 9), with moderate meadows found at Pelican Banks (meadow 43) and Wiggins Island (meadow 5) (Chartrand *et. al.*, 2009).

Ephemeral seagrass meadows were identified on the mainland side of Curtis Island during monitoring undertaken in 2002 (Figure 3-3) (Rasheed et al, 2003), however ongoing monitoring of these meadows has not been undertaken by PCIMP possibly due to their ephemeral and highly patchy nature.

Key impacts on seagrasses from dredging include physical removal or burial of vegetation at the dredging/disposal site, increased turbidity and increased sedimentation in adjacent seagrass meadows, temporarily reduced dissolved oxygen concentration, release of nutrients and pollutants from contaminated sediments and hydrographic changes (Erfemeijer and Lewis 2006).

While the minimum light requirement of seagrasses in the area is important, the duration of the period of sub-optimal light is also of importance (Erfemeijer and Lewis 2006). The survival period for the seagrasses found in the study area is approximately one month at sub-minimal light conditions. *Halophilia ovalis* has been documented to cope with sub-optimal light for the shortest period of the seagrasses found in the study area (Erfemeijer and Lewis 2006). Therefore the survival period for this species should be used as a minimum conservative value. While dredging operations will increase light attenuation, the effects are expected to be transient in most areas according to modelling results.

As stated in the DMP (Attachment G9) of the Supplementary EIS the proposed dredging and reclamation discharge for GLNG will indirectly impact a relatively small area of intertidal mudflat near to South Passage Island. There is also the potential for increases in suspended solids to reduce light attenuation and affect photosynthesis of plants. Any increase in sediment deposition rates beyond the natural variability that the seagrass are adapted to could also cause significant adverse impacts and result in decline or die back of the plants.

For the dredging from the standalone GLNG proposal to impact the areas where seagrass meadows are located, such as the mainland side of Curtis Island and adjacent to the mainland (Fisherman's Landing) and Wiggins Island, there needs to be a mechanism to transport suspended solids from the input location to the reception area. Attachment G5 of the Supplementary EIS shows results from plume dispersion studies where sediment plumes move with tidal flow, spreading gradually but continuously decaying. The plume dispersion studies do not suggest that there will be measurable increases in suspended solids levels at the intertidal areas on Curtis Island or on the mainland adjacent to Fisherman's landing. Maximum and 90th percentile TSS concentrations for the CSD are generally high (> 100mg/L above background) at the plume source/s and decrease with distance from these locations.

The 10% exceedance predictions for TSS concentration (refer Figure 5.4; Attachment G5) provides more information on the potential duration of impact. The data shown in this figure indicates that for 10% of the time TSS concentrations will exceed 100mg/L at the dredger head and be in the order of 30 mg/L in the immediate vicinity of the dredger. These concentrations diminish to approximately 5 mg/L in relatively close proximity to the proposed dredging channel. During neap tide the concentration will exceed 100mg/L at the dredge head but that the predicted dredge plume will be confined to the immediate vicinity of the dredger. During spring tide, TSS concentrations are unlikely to exceed 20 mg/L in area surrounding the dredger (Refer Table 5-3; Attachment G5).

Dredging carried out by the CSD will result in low losses into the water column at the dredge site as these dredgers do not overflow material and losses are limited to disturbance at bed level by the cutter head. The CSD would however, be permanently connected to the pipeline for continuous discharge into the placement facility. Correspondingly there is the potential for the discharge from the placement facility to flow continuously. The CSD will input material into the lower part of the water column rather than the surface and while a plume may be visible in shallower water the suspended sediment is likely to settle more quickly and be distributed less widely. This limits the likelihood of impacts at the intertidal margins of Port Curtis. However, to minimise the risk to the sensitive seagrass and mangrove habitats, it is proposed to set suspended sediment threshold limits. The contractor will be expected to plan dredging activities to comply with these limits.

The deposition modelling results indicate that dredging activity has the potential to contribute to increased deposition rates within Port Curtis. Increased rates in the order of 1mm/d are anticipated at the dredge head and 0.1mm/d in close proximity to the dredger (Refer Figure 5.15; Attachment G5).

Increased rates in the order of 0.02 mm/d are predicted in the channel between the Passage Islands and Curtis Island which represents a 4% increase on background deposition rates (Refer Table 4.8; Attachment G5).

In order to assess the depositional impacts of the proposed dredging activity on sensitive receptors time series graphs of plume deposition were produced for each receptor site. These graphs are provided in Appendix B in Appendix A of Attachment G5. Average sediment deposition rates were derived at each site based on the final 2-weeks of the 1 month simulation, where suspended sediment mass levels were seen to have reached a dynamic saturation level. The average deposition rates predicted at each sensitive receptor location for the CSD are provided in Attachment G5.

Changing the depths or form of coastal and marine areas can sometime result in changes to tidal flows and consequently erosion and sedimentation patterns. The EIS modelled the effects of the GLNG project and concluded that the tidal hydraulic impacts will be minimal and is discussed in Section 8.7.4.5 of the EIS. It is unlikely that significant impacts will occur to the sensitive intertidal areas. However there is the potential for indirect impacts from increases in suspended solids in the water column leading to reduced light attenuation or smothering from increased levels of deposition.

When the predicted maximum TSS increase is overlaid on Figure 1, remembering that these seagrass meadows were present in 2002 with no ongoing monitoring, it is evident that potential impacts to seagrass meadows from elevated TSS and deposition of sediments include those meadows identified as 30 & 31 in the Rasheed *et al.*, (2003) results. Other seagrass meadows located adjacent to the mainland, Wiggins Island, Quoin Island and Pelican Banks are unlikely to sustain any potential impacts from dredging activities.

4.1.2 Marine Dredge Material Placement Facility

Potential impacts to marine fauna from construction and operation of the DMPF may occur through avoidance of the area due to noise and vibration from pumping the dredge material to the DMPF site and reductions in water quality during construction. The DMPF will be designed and managed to ensure that the quality of discharge water complies with the relevant environmental authority approval conditions.

Potential impacts to seagrass meadows are not anticipated from construction of the DMPF. The bund wall will be designed for a 1 in 100,000 catastrophic event.

4.1.3 Gas transmission pipeline

Pipeline

Pipeline dredging works are proposed to be undertaken using a backhoe hydraulic dredger (BHD). Based on a predicted backhoe productivity of 150m^3/h and a spillage rate of 10kg/m^3, it is anticipated that the BHD will generate a plume at the rate of 1500kg/h (0.42kg/s). The predicted long-term fraction of the plume and its composition were derived based on data on the characteristics of the material to be dredged and monitoring undertaken during dredging works by the “Wombat” CSD. It is assumed that 100% of the entrained fine sand and silt will remain suspended in the long term plume while 0% of the gravels and coarse sand fractions will remain in suspension.

Hydrodynamic modelling was undertaken to assess the potential water quality impacts associated with pipeline laying across Port Curtis using the software package TUFLOW-FV.

Two pipeline scenarios were modelled one for pipeline laying on the eastern side (Figure 4) of the channel and the other for pipeline laying in the western side (Figure 5) of the channel.

The results of the modelling are shown as 90th percentile (10% exceedance) plume concentrations above background TSS levels Figure 4. These results are discussed further detail in the Port Curtis Water Quality Report (Attachment G5 of the Supplementary EIS).

The modelling results show that during pipeline laying operations 90th percentile TSS concentrations above background are anticipated to be below 2mg/L away from the dredger. The predicted increases in TSS concentrations are minor and are not anticipated to result in any detectable impact.

When the predicted maximum TSS increase is overlaid on Figure 3.3, it is evident that impacts on seagrass communities are limited, with only communities identified as 30 & 31 receiving some elevation in TSS.

Potential impacts from trenching and back filling activities to turtles and dugong may occur during the construction phase. Potential interactions with the backhoe are considered to be unlikely. Dugong and turtle may display avoidance behaviour during excavation and backfilling operations due to noise and vibration and an increase in TSS.

4.1.4 Vessel movements

Potential impacts from construction of the LNG facility will include increased vessel traffic for the transportation of materials, equipment and staff. This may result in increased risk of boat strike to turtle and dugong that could lead to increased mortality and injury. High vessel traffic in shallow coastal areas has been shown to cause serious injuries and mortalities to dugong and turtles (Greenland and Limpus, 2006). Hodgson (2004) showed that dugong were particularly susceptible to interactions with large high speed vessels due to a delayed response displayed by dugong. During this study the depth profile of the area was also a contributing factor where dugong were more prone to interactions with vessels in shallow areas (Hodgson, 2004). Dugong mothers and calves were also reported as spending more time at the water surface rendering them more susceptible to possible interactions with vessels (Hodgson, 2004). It is anticipated that vessels used to ferry workers to Curtis Island will be large (150 passengers) and capable of high speeds (up to 25 knots). Maintaining constant watch while in operation and reducing ferry speeds will mitigate potential impacts to dugongs and turtles.

Disturbance to normal feeding patterns may also result from increased vessel activity. Hodgson and Marsh (2007) showed that dugong feeding on large seagrass meadows resumed feeding activity within 2 minutes of disturbance from vessel activity. This pattern was observed to be different for dugong feeding on smaller seagrass meadows with significantly reduced time available for feeding (reduction in habitat quality) and displacement from an important feeding area (reduction in extent of habitat). Marsh and Kwan (2008) showed a reduction in dugong reproductive potential (fecundity) in response to poor habitat quality or seagrass availability.

Increased levels of petroleum hydrocarbons and anti-fouling residues in coastal waters and significant amounts of ship-borne litter may potentially impact turtle and dugong health (refer Appendix A). Some hydrocarbon compounds are highly hydrophobic, and once in the water column, tend to adsorb to fine particulates or be bio-accumulated in lipids in aquatic biota (Olsen et al. 1982). Tissue accumulation of hydrocarbons has been implicated in reproductive and immunological abnormalities observed in marine mammal populations (Boon et al. 1992). According to Haynes *et al* (1998b*)* it has been shown that fat tissues and liver in dugongs can accumulate hydrocarbons. Dugong may suffer from long term effects such as liver problems if they consume hydrocarbons floating on the surface or oil-affected sea grasses. Depending upon the amount and composition of the ingested oil, the effects could range from acute, to subtle, to progressive organ damage (AMSA, 2009). Please refer to Section 13.16.8 of Attachment B3 for proposed mitigation measure to manage hydrocarbon releases to surface waters.

Other water quality issues are also discussed in the DMPF Water Quality Report (Attachment G5).

4.1.5 Lighting and flaring

Lighting will be used on the ships, access roads, PLF, MOF, LNG facility, dredges and support vessels and flaring activities. Flaring typically lasts for several hours at a time at irregular intervals throughout the year for maintenance purposes and in emergency situations. Lighting has been linked to disorientation in turtles, particularly during periods of nesting and hatching (Lutcavage *et. al.,* 1996; Pendoley, 1997). Studies reported by Witherington (1992) on orientation of hatchlings revealed the most disruptive wavelengths were in the range of 300-500 nanometres (nm). Light emitted from a natural gas flare has peaked spectral intensity of 750-900 nm (WAPET, 1995).

Changes in the light horizon caused by light emissions from the GLNG Project are expected to be minimal due to the current levels of lighting from existing industrial areas in Gladstone. A change to the light horizon refers to altered reflected illumination of the night sky above the LNG facility. Any potential impacts to nesting turtles at the southern end of Curtis Island from the LNG facility increased light illumination will be mitigated through implementation of measures such as the use of low sodium lighting and light hoods.

The EIS notes that visibility of the flare stack lies just outside of the location of turtle nesting beaches on South End, Curtis Island although it would be partially visible from the South End and Facing Island townships (refer to EIS, Section 8.12, Figure 8.12.2) . Section 8.8.5.1 of the EIS notes that flaring will only occur during plant upset conditions or scheduled shut down and start up for maintenance. Potential impacts to nesting turtles and hatchlings from gas flaring activities will only occur during flaring events at night time in the turtle nesting season. The need to minimize light emissions will be taken into account during finalisation of the LNG facility In the event there is a direct line of sight from the stack to nesting turtle populations, or light glow from the LNG facility is considered to potentially impact nesting turtles and hatchling behaviour following detailed design, or gas flaring occurs at night during turtle nesting season, a turtle monitoring program will be implemented.

4.1.6 Human presence

Increased pressure from human presence from the construction and operational phases of the GLNG Project will be kept to a minimum. All workers staying on Curtis Island will be confined to the LNG facility and CAF footprint and access to areas outside of the GLNG Project footprint will not be permitted.

4.2 Management Actions and Strategies

The management actions and strategies that will be implemented during the construction and operation phases of the Santos GLNG Project development are outlined in Appendix A. In addition, management strategies are also detailed in the LNG facility EMP (refer Attachment B3).

Section's 4.2.1 and 4.2.2 below specifically detail the actions and strategies to be implemented in the event of potential disturbance or interaction with sea turtles or dugongs from dredging operations and interference through increased lighting.

If required, monitoring key populations of turtles that nest and forage around Curtis Island will be designed and implemented in accordance with the *Marine Turtle Recovery Plan 2003*. A national monitoring program managed jointly by the Commonwealth, States and Territory provides benchmarks for critical population parameters such as annual recruitment and hatching success. Most monitoring will be confined to nesting beaches because of the accessibility of nesting females.

The management implications to be considered for turtles and dugong and impacts arising from the GLNG Project include the following issues:

- Vulnerability to both short-term (acute) impacts and cumulative (chronic) impacts;
- Vulnerability to boat strike due to the extent and frequency of time spent on the surface of the water;
- Avoidance of interactions with marine fauna and the dredge head;
- Mitigation of potential impacts to seagrass meadows;
- Monitoring (if required) aimed at determining accurate population counts of nesting turtles on Curtis and Facing Island will determine the effectiveness of management strategies adopted as a result of the potential impacts from the Project; and
- Adhering to reporting requirements for any interactions with turtles and dugongs.

The LNG facility EMP will include guidelines for rubbish and waste disposal that adhere to waste management plans and measures including provision of solid waste containers for recycling or disposal via a licensed contractor. Onsite users will be educated in regards to appropriate waste management requirements.

Potential impacts from noise and vibration from construction activities below the high water mark and ongoing operational activities are possible. Marine fauna observation procedures during piling operations will mitigate potential direct impacts to turtles and dugong although avoidance behaviour will be likely. Standard navigational controls for vessels will be employed.

Attachment G9, Strategy 3 details mitigation measures that focus on keeping a lookout for dugong and turtles and implementing an agreed series of actions should they be sighted within a specified distance of the dredger. The aim of the management strategy will be to minimise the potential for collision with the vessel or draghead and to reduce disturbance associated with underwater noise from dredging or use of sonar. The management of suspended solids levels to protect intertidal areas and for general water quality (refer to Sections 5.3.4) will also ensure protection for dugong and turtles and adjacent sub-tidal and intertidal communities.

Decreases in water quality from dredging, construction and other project related activities include:

- Monitoring of sensitive receptors such as water quality prior to, during and after dredging;
- Monitoring of discharges to ensure water quality levels meet appropriate guidelines; and
- Spill response equipment and appropriate training of personnel and spill response plan.

Adoption of the Water Quality Management Measures discussed in the DMPF Surface Water Report (Attachment G4) and the LNG facility EMP will be undertaken.

4.2.1 Capital and maintenance dredging

In accordance with the requirements of the *Coastal Protection and Management Act 2005* a Dredge Management Plan (DMP) has been prepared aligned with the *National Assessment Guidelines for Dredging 2009* and the *Approval of a dredge management plan guideline* developed by DERM (refer Attachment G9 for details).

The DMP incorporates appropriate approaches including the following:

- Minimise the dredge footprint;
- Monitoring of water quality conditions;
- Use of water quality triggers to halt dredging operations if declines in water quality exceed acceptable levels. Halting dredging operations may also occur in the event that turtles or dugong approach the dredge vessel within 50 m;
- Trained marine fauna monitors on vessels during dredging operations;
- Monitor for presence of turtles and dugong during periods of high activity; and
- Reporting requirements.

In advance of scheduled dredging activities, the designated crew for the dredge vessel will receive training from an Independent Fauna Observer (IFO). In the absence of the IFO the vessel captain is responsible for ensuring that sighting and injury/death reporting is logged by a designated crew member. These procedures must be followed as part of any dredging and dredge material placement procedure.

A turtle and dugong watch will be maintained at all times from all dredging/support vessels involved with dredging. In the event that turtles or dugongs are sighted, all vessels and piling operating in the area will be notified. The fauna presence including direction and behaviour will be monitored and dredging operations may cease if required. Sighting of sick or injured turtles will be reported to the DERM Hotline (refer Section 5.3.1 of this report). Soft start procedures prior to commencement of piling activities will mitigate potential impacts caused by turtle startle response and movement from the area.

Potential interactions with turtles and dugong from increased shipping activities will be mitigated through maintaining watch, monitoring for presence of turtle and dugong during periods of high activity and adhering to all reporting requirements. The use of a dedicated navigational channel for LNG Carriers during the operational phase of the Project may minimise potential interactions with turtles and dugong through possible long term changes to behaviour resulting from frequent shipping activity in the navigation channel.

Capital dredging operations associated with the construction of the navigation channel, PLF and MOF will decrease water quality in the vicinity (refer Section 4.1.1 of this report).

To minimise the risk to the sensitive seagrass and mangrove habitats, it is proposed to set suspended sediment threshold limits for the placement facility discharge and at representative sensitive receptor sites. The contractor will be expected to plan dredging activities to comply with these limits. A bathymetric monitoring programme will also be implemented to validate the prediction that no significant deposition will occur at these areas.

Mitigation will involve selecting and planning dredging and discharge activities to maintain losses of suspended solids to an acceptable level. A suspended sediment management strategy will be implemented with agreed thresholds for suspended sediment levels at the placement facility discharge point and at selected sensitive receptor sites. Soft start procedures during piling for the PLF will be used.

On-land disposal of dredge material at the DMPF and mitigation of potential impacts are discussed in the DMPF Report (Attachment G4).

4.2.2 Marine Dredge Material Placement Facility

No impacts to turtle and dugong are anticipated from the construction of the DMPF. Seagrass adjacent to Laird Point was found to be ephemeral and highly patchy during annual monitoring in 2002 (Rasheed *et al.*, 2003), however ongoing monitoring of seagrass has not occurred as part of the long term monitoring program due to the highly patchy and ephemeral nature of seagrass found at this location (Rasheed *et. al., 2008)*. All associated de-watering of dredge material will be treated through retention ponds and water quality monitoring of the receiving waters will be conducted during the construction and operational phases of the project.

4.2.3 Gas transmission pipeline construction

Marine fauna activities will be visually assessed and if a sighting occurs when, excavating and backfilling, especially during periods of high activity or nesting management procedures will be enacted. Procedures will be developed to ensure a dugong and sea turtle watch is maintained in the area before activities commence.

4.2.4 Vessel movements

Mitigation of potential impacts from vessel strike is discussed in Appendix A.

The following mitigation measures for any potential interactions with turtles and dugong with Port Curtis include:

- Monitor for presence of dugongs and turtles during periods of high vessel activity;
- The use of the dedicated navigational channel for LNG Carriers during the operational phase of the project;
- Stringent management controls for all vessel movement within the Port;
- Spill response plan and equipment and appropriate training of personnel; and
- Adherence to National Guidelines for Whales and Dolphin Watching for Construction Phase.

Varying boats of different speeds are anticipated to be used for the GLNG Project. The final boats to be utilised during the GLNG Project will be dependent upon boat and contractor availability. This issue is recognised to be much broader than the GLNG Project alone, given that most boat strikes occur from faster boats i.e. smaller fishing vessels within Port Curtis. Santos will contribute to any process to assess improvements to speed management of vessels in the Gladstone Harbour. This may target areas of speed restrictions to minimise the potential impact of boat strike to turtles and dugong in the Gladstone Harbour. Further mitigation measures include the implementation of an education program for the construction workforce regarding the risks to turtles and dugongs. This program will include instructions on avoiding interaction with these species. Further mitigation measures to reduce impacts on marine megafauna are included in the LNG facility EMP (Section 13.16.4, Attachment B3). It is anticipated that utilisation of these mitigation measures will reduce the potential of boat strike to a low level of impact.

4.2.5 Lighting and Flaring

The detailed design phase will ensure that all lighting associated with the LNG facility (and associated infrastructure) is minimised and tailored for its intended use by applying the following procedure (refer to EIS Section 8.12). Interference through light glow from the LNG facility site and associated shipping may require mitigation. Modification of lighting to mitigate potential impacts to turtles include:

- Reduction in the intensity of light glow using low pressure sodium (LPS) lights;
- Using timers;
- Installing movement sensitive lights; and
- Restricting the height of available light or applying shrouds to control direction.

Due to the location of occasional nesting on the ocean side of southern Curtis Island and Facing Island, the impacts on nesting turtles from increased lighting caused by gas flaring for maintenance purposes will be mitigated using measures such as avoiding, wherever possible, flaring at night and avoiding turtle nesting and hatching season, where practicable. Emergency flaring may occur at any time however only during plant upset conditions (controlled relief emergency shut down) or scheduled shut down and start up for maintenance. A flare pilot will remain on at all times (although this is not bright enough to cause a negative impact). For the rare events (i.e. controlled relief, emergency shutdown, warm ship load out occurring at night during turtle hatching season),

Current design indicates there is no direct line of sight between the turtle nesting beaches on Curtis Island and gas flaring activities. The final design of the flare stack will have regard to the need to minimise potential line of site to the turtle nesting beaches.

4.2.6 Human presence

Staff on Curtis Island will be restricted to the LNG footprint therefore any direct impacts are considered unlikely.

4.3 Contingency Actions

Santos recognises that contingency measures and adjustments to the management strategies may need to be considered in the event that a detrimental impact is recorded, and/or performance measures or targets are not met. In the event that turtle injury or hatchling disorientation is recorded the current mitigation strategies will be reviewed in conjunction with a turtle specialist and any recommended changes implemented. Any new mitigation measures will be discussed with DERM prior to implementation.

Monitoring, Auditing and Reporting

5.1 Responsibility

For the life of the project, Santos will monitor potential impacts upon turtles and dugongs, that may involve contracting specialist consultants to undertake any observations, sampling, analysis and other monitoring works as required. Monitoring programs will be designed to align with the objectives of the Marine Turtle Recovery Plan 2003 (Cwlth).

Santos will ensure that all employees, officers, subcontractors and agents associated with the project, including the dredging contractor, are educated about the approved Turtle and Dugong Management Plan, including the relevant permits and that they comply with it's requirements. As the Plan is aligned with the *Environmental Protection and Biodiversity Conservation Act 1999*, the *Marine Turtle Recovery Plan 2003* and *Shoalwater Bay (Dugong) Plan of Management 1997*, Santos is required to ensure environmentally sound practices are implemented during all activities.

An Independent Fauna Observer (IFO) will be placed on key dredge vessels on at least two days per month during December – May, every year until construction is complete.

The training, logging and reporting of turtle and dugong observations and incidents will be undertaken by trained marine fauna observer/s.

5.2 Monitoring

5.2.1 Nesting Turtle Monitoring Program

If a direct line of sight is established between the gas flaring activities and turtles nesting beaches and in the event of prolonged flaring events within turtle nesting season the sea turtle monitoring program for identified turtle species that nest on beaches within the predicted line of site of flaring activities at the southern end of Curtis Island will commence. Evidence of nesting, digging or crawling will be identified by sea turtle observers from an observation point located centrally with binoculars. Daily inspections will be conducted between 6am and 9am to identify and record turtle nesting activity.

At the inception of a monitoring plan, data collection will include date, species, time of observation, name of the person monitoring, nesting activity, location and type of nesting activity and provided immediately to the Environmental Advisor when identified, or otherwise weekly. At the inception of monitoring activities an independent sea turtle biologist will undertake a site visit to review the adopted monitoring approach and provide guidance to Santos and the sea turtle observers on identification and any other improvements that may enhance the accuracy and reliability of the program. The primary objectives of the initial visit by the turtle biologist will ensure that all personnel involved in the sea turtle monitoring program have a general understanding of:

- Sea turtle biology in the Curtis Island region;
- Key aspects of sea turtle breeding and nesting;
- Key aspects of sea turtle identification (juvenile and adult) (Appendix B);
- Key aspects for ensuring minimal disturbance to sea turtles; and
- Based on a site inspection, any other improvement deemed necessary to ensure valid and scientifically sound data is generated.

This initial visit will be followed by an annual review (i.e. between Nov-May) by a turtle biologist. The site Environmental Advisor will be available on a daily basis for additional support. Each incident will be reported separately into the Santos Incident Management System (IMS).

5.2.2 Monitoring of potential impacts from dredging

The following monitoring requirements have been developed and recommend in Attachment G5 and are summarised below:

- Monitor water quality, sedimentation rates and seagrass health prior to, during and after dredging;
- Monitoring of sediment spill and comparison with defined spill budgets during dredging operations; and
- Results of WQ, Sedimentation, seagrass health and sediment spill to be used to guide dredging operations and management.

5.2.3 Turtle and dugong records

As part of dredging, trenching, piling and rock fill operations, sea turtle and dugong observations will be recorded in a daily log book. Prior to commencement of these activities, an Independent Fauna Observer (IFO) will be identified and a briefing from the site dredging environmental advisor will be undertaken to ensure the observational and reporting requirements are understood. It will be expected that individual turtle and dugong sightings will be recorded, and species identification will not be required. The monitoring will feed back into the management strategy to allow the strategy to be revised if adverse effects are observed that it can be reasonably believed to arise from the dredging activity.

5.2.4 Operational Monitoring Program

The specific requirement for ongoing sea turtle and dugong monitoring at the identified locations will be assessed following the completion of the construction monitoring program. Long-term monitoring activities will be discussed and agreed with DERM and DEWHA six months prior to the first nesting season during the operational phase, and implemented during the first season. Specifically, discussions will focus on monitoring in relation to:

- Detecting trends over time in turtle nesting; and
- Determining whether the potential light-related impacts might be affecting nesting and hatchling behaviour.

5.3 Reporting and auditing

During construction and operations, compliance audits will be conducted by Santos in accordance with the requirements of this EMP as well as construction procedures, relevant legislation, license and permit conditions and industry standards. To ensure appropriate stakeholders are adequately informed of relevant EHS performance, reports, where necessary, will be prepared for internal and stakeholder review.

5.3.1 Construction and Operation

Any incident that involves the injury or mortality of a turtle or dugong will be reported immediately to the DERM Hotline below.

Any recovered remains will be used by a turtle biologist for species identification.

The contact details for DERM Turtle and dugong incident reporting are:

The Department of Environment and Resource Management

Hotline: 1300 130 372 – Option 3 (marine strandings or deaths)

In addition, a report on monitoring of nesting activities at the identified nesting location during construction will be provided to DERM within one month of the end of the nesting season.

Any recovered remains will be used by a turtle biologist for species identification.

5.4 Review

This Management Plan will be reviewed regularly to ensure that the conditions and objectives outlined in Section 1.1 are being met.

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Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 15th July 2009.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 21 September 2009 and 9 October 2009 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A Turtle and Dugong Management, Strategies and Actions Summary Table

APPENDIX A

Marine Turtle and Dugong Management Issues, Actions and Strategies Summary Table

Issue/Aspect	Activities	Potential Impacts	Objective	Actions	Performance Measures
Lighting and flaring	**Construction of the LNG Facility, MOF, PLF, DMPF, pipeline and associated dredging and shipping activities.**	Due to the proximity of the construction to turtle nesting beaches it is considered unlikely that lighting could disrupt turtle nesting activity (i.e. deter females from entering the beach) or lead to disorientation of turtle hatchlings. The potential (acute) impacts include: - Disorientation of turtle hatchlings through interference from lighting required for construction; - Turtle hatchlings may be attracted to the lights on boats/barges moored offshore at night; and - Avoidance behaviour of breeding turtles due to interference from lighting. The potential consequences of disturbance to normal turtle nesting behaviour may lead to failure of females to nest and disturbance to egg clutches creating changes in temperature impacting sex determination and possible egg mortality. The potential consequences of disorientation of turtle hatchlings and subsequent interruption to normal behaviour of hatchlings returning to the sea, results in hatchlings not receiving critical environmental cues required for their future return to their natal beaches having reached maturity and ready for breeding. Cumulative impacts (chronic) from existing lighting from Gladstone City, local industry and shipping may be increased by the addition of the LNG Facility construction. Vessel lighting may attract hatchlings in the water over a small area around a vessel with the potential for higher predation rates and localised increase in hatchling mortality. Lighting from nearshore and onshore activities may attract hatchlings leading to a localised increase in hatchling mortality. Lighting from nearshore and onshore activities interfering with normal nesting behaviour.	To minimise impacts from lighting on Nesting, inter-nesting and foraging sea turtles and hatchlings.	Assessment of light intensity levels in near shore areas and on vessels, and where practicable avoid lighting spill through the use of shielding, directional/downward facing lighting and other techniques. Take particular care during late October to end January, nesting season of the following three species of marine turtles known to nest on Curtis and Facing Islands: • Loggerhead nesting: late Oct – early Dec • Flatback nesting: late Nov – end January • Green nesting: late Nov to end January Monitoring during nesting season and relocation of hatchlings if necessary (re-assess after the first season).	Turtle activity (both adult and hatchlings) is not noticeably altered in the area, through disorientation caused by lighting. No recorded incidence of turtle hatchling concentrations around light installations

		Potential impacts to dugong from increased lighting are considered to be negligible. There is currently no evidence to suggest that light potentially impacts dugong behaviour.	To minimise potential impacts to dugong from lighting.	Record any interactions between dugong and lighting	Any changes to dugong behaviour or signs of stress during the construction phase
Vessel Movement	**Construction and Operation** **Vessel movement - dredgers, shipping vessels, LNG carriers, pipeline laying vessels - construction, operation and decommissioning vessels and barges**	Potential impacts include: - Increased risk of vessel strike; - Direct impacts on fauna from vessel movement (eg boat strikes) leading to injury or mortality. - Behavioural changes (migration, foraging, breeding) leading to avoidance of area; - Heightened community / regulator concern; - Propeller wash impacting benthic habitat; - Toxicity effects of TBT on turtle and dugong health	To minimise the impact of vessel movement on sea turtles and dugong	• Monitor for presence of dugongs and turtles during periods of high activity; • Dedicated navigational channel for LNG Carriers; • Controlled vessel speed within Port limits; • Maintain constant watch to avoid interactions with marine turtles and dugong; • Adherence to National Guidelines for Whales and Dolphin Watching for Construction Phase	No turtle or dugong mortality associated with vessel movement activities during the construction and/or operational phases of the project. No loss of habitat beyond those predicted.
	Ballast Water – shipping vessels, LNG Carriers	Introduction of exotic species and pathogens	To avoid potential impacts from introduced species and pathogens	• No discharge of ballast in nearshore areas • Vessel hull inspections	No increase in disease
	Cathodic protection	Accumulation of Zinc	To minimise impacts from accumulation of zinc	• Controlled shipping schedule to minimise time in port	No zinc accumulation
Dredging and spoil placement	**Capital – navigational channel, pipeline, berthing area**	• Changes to water quality leading to detriment to marine turtles and dugong; • Increased turbidity leading to changes to behaviour and avoidance of the area; • Turtle and dugong interaction with dredge head causing injury or mortality; • Suspended solid plumes may reduce visibility in sea turtle and dugong foraging habitat.	To minimise the impact of Dredging activities on marine turtles and dugong	Minimise the dredge footprint; Dredge Management Plan including mitigation measures to minimise interactions with turtles and dugong (refer Strategy 3: Attachment G9); Timing of dredging. Maintain constant watch during dredging operations Cease dredging if within 50m of dredge gear **Monitoring** (refer Attachment G5): - Monitor water quality, sedimentation rates and seagrass health prior to, during and after dredging;	No turtle or dugong mortality associated with dredging activities

				- Monitoring of sediment spill and comparison with defined spill budgets during dredging operations; - Results of WQ, Sedimentation, seagrass health and sediment spill to be used to guide dredging operations and management.	
	Maintenance	• As above	To minimise the impact of dredging activities on marine turtles and dugong	As above	As above
Noise and Vibration	**Construction and operation**	• Interference with communication • Changes to nesting, inter-nesting, foraging, courting and mating behaviour • Avoidance of area	To minimise the impact of piling and construction activities on sea turtle including nesting and hatchling activity	• Marine fauna activities will be visual assessed and if a sighting occurs when, drilling and/or dredging, especially during periods of high activity or nesting management procedures will be enacted. • Procedures will be developed to ensure a dugong and sea turtle watch is maintained in the area before activities commence. • Soft start procedures for piling operations	No turtle or dugong mortality associated with construction and operation activities

Appendix B Marine Turtle Identification

Great Barrier Reef Marine Turtles

Loggerhead Turtle *(Caretta caretta)*

Did you know . . . Loggerhead turtles get their name because of their large square heads and strong jaws.

Olive Ridley Turtle *(Lepidochelys olivacea)*

© Scott Handy

Did you know . . . Olive Ridley turtles are the smallest of all the marine turtles and their shell is shaped like a heart.

Leatherback Turtle *(Dermochelys coriacea)*

© Scott Handy

Did you know . . . Leatherback turtles are the largest of all the marine turtles with a leather-like shell up to 2.5m in length.

Hawksbill Turtle *(Eretmochelys imbricata)*

Did you know . . . Hawksbill turtles have thick overlapping scales and a distinctive beak. Their shell was once used to make ‘tortoiseshell’ jewellery.

Flatback Turtle *(Natator depressus)*

Photo: Scott Whiting

Did you know . . . Flatback turtles have a very flat shell with upturned edges. The species is only found on the Australian continental shelf.

Green Turtle *(Chelonia mydas)*

Did you know . . . Green turtles get their name because their fat is coloured green. They mainly eat algae and other marine plants.

Egg Facts Marine turtles lay between 50 and 200 eggs per clutch. Eggs take about 60 days to hatch.

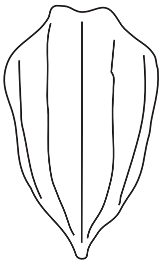
Australian Government
Great Barrier Reef Marine Park Authority

our great barrier reef
let's keep it great

Identification Key

The identification key below will help you identify the marine turtles of the Great Barrier Reef. Follow the flow chart and match the carapace (shell) and/or the pre-frontal scales on the head to the turtle in question.

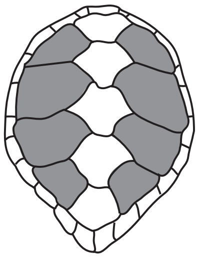
Carapace ridges, no scales



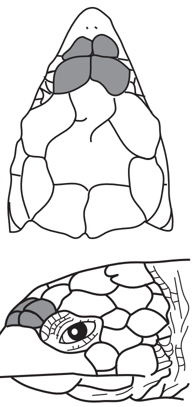
Leatherback

Carapace scales

4 pair costal scales

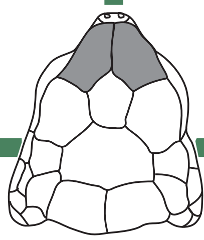


2 pair pre-frontal scales
Thick overlapping carapace scales

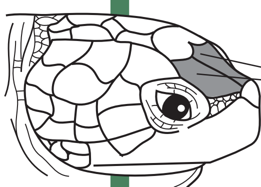


Hawksbill

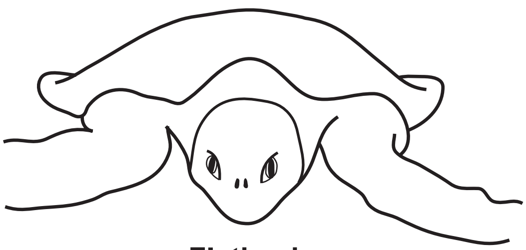
1 pair pre-frontal scales
No thick overlapping carapace scales



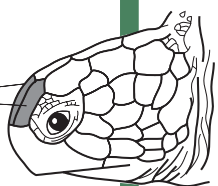
1 pair pre-frontal scales



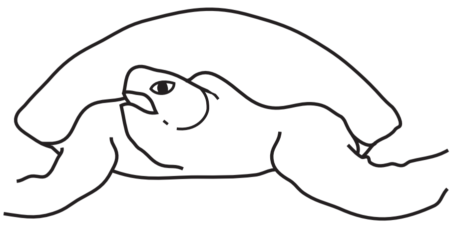
Carapace low domed
with upturned edges
Colour olive grey



Flatback

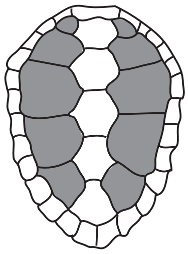


Carapace high domed
Colour light to dark green
with dark mottling



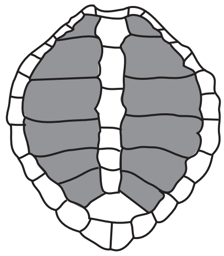
Green

5 pair costal scales
Colour red-brown to brown



Loggerhead

6 pair costal scales
Colour grey-green



Olive Ridley

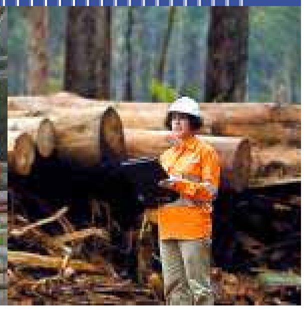
Australian Government
Great Barrier Reef
Marine Park Authority
2-68 Flinders Street
PO Box 1379 Townsville, Qld 4810.
1800 990 177
www.gbrmpa.gov.au

Please report sick, injured, stranded or dead turtles to the EPA Hotline
1300 130 372.

CE649







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Part 4 Potential Coral Loss

Report

Assessment of soft coral and sponge communities, Port Curtis

NOVEMBER 2009

Prepared for

Santos

32 Turbot St
Brisbane QLD 4000

42626446

URS

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Reviewer:	.... Jim Barker Associate Environmental Scientist	Date: Reference: Status:	**November 2009** 42626446/01/C Final

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Table of Contents

Tables

Figures

Plates

Abbreviations

Abbreviation	Description
AIMS	Australian Institute of Marine Science
ANOVA	Analysis of Variance
AVTAS	AIMS Video Transect Analysis System
DEWHA	Department of the Environment, Water, Heritage and the Arts
DMPF	Dredged Material Placement Facility
EIS	Environmental Impact Statement
EMP	Environmental
GBR	Great Barrier Reef
GDA	Geocentric Datum of Australia
GLNG	Gladstone LNG
LNG	Liquefied Natural Gas
MOF	Materials Offloading Facility
MSL	Mean Sea Level
NTU	
PLF	Product Loading Facility
Santos	Santos Limited
SCUBA	self contained underwater breathing apparatus
SE	standard error
TSS	Total Suspended Solids
URS	URS Australia Pty Ltd

Introduction

1.1 Background

Estuaries found in Australia are more variable compared to those found in other parts of the world. This variability reflects a combination of the extreme hydrology of Australian rivers and the geomorphology of Australian estuaries, which are shallow due to tectonic stability and low coastal relief (Eyre, 1998).

Port Curtis is a macro-tidal estuary with large barotropic tides having ranges up to 4 m. The tide propagates into the estuary through the straits separating Facing Island from the mainland (Gatcombe Channel) and Curtis Island (North Channel) in the south-east, and through the Narrows in the north. Maximum currents during the spring phase may be as large as 2 ms^{-1} in North Channel (Witt & Morgan, 1999). The large tides ensure that the water column is vertically well mixed most of the time, and are responsible for significant resuspension of fine sediment. Combined with very large deposits of silt from the hinterland in times of flood, the estuary maintains a highly turbid character (Herzfeld *et. al*., 2004).

The region is characterized by extensive areas of tidal flats that become exposed at low tide and large areas of mangroves fringing the estuary. Abiotic factors are important in explaining patterns of estuarine community structure (Hirst, 2004). Subtidal communities are often considered as being poor ecosystems and have received little interest, however reefs with high cover, and in some cases high diversity, do occur in episodically turbid near-shore waters. These soft corals and associated communities have ecological significance, being home to numerous aquatic fauna and flora (Herzfeld *et. al*., 2004).

These ecosystems remain poorly studied as most of the scientific attention is given to mid-shelve and off shore coral reef ecosystems. Detailed studies on tropical estuaries are relatively scarce compared to coral reefs. The need to obtain baseline data on species richness and abundance, as well as the spatial distribution of these habitats has been recognised as necessary to support the decision making process involved in conservation efforts (Dittman, 2002; Zacharias & Howes, 1998). Managing these ecosystems is therefore a challenge as the habitat and its processes are poorly understood.

1.2 GLNG Dredging Overview

1.2.1 Product Loading Facility

To enable LNG vessels to access the PLF it will be necessary for an access channel to be dredged from the existing Targinie Channel in Port Curtis which is currently used to provide shipping access to the RG Tanna Terminal and is to be extended to provide access to the proposed Wiggins Island Terminal.

The capital dredging comprises two parts; i) the dredging of a new North China Bay approach channel to the proposed LNG facility from the existing Targinie Channel and ii) the creation of a berthing and manoeuvring area at the LNG facility. The total volume to be dredged is 6.8 million m^3, the large majority of which (~5.7 million m^3) is associated with the creation of the berthing and manoeuvring area and is expected to take approximately 41 weeks. (refer to Attachment G9 of the EIS Supplement). The new berth and manoeuvring area will be dredged to -13.5m LAT at the PLF to enable ships to manoeuvre safely. The dredge footprint is approximately 620,000 m^2. Approximately 5.7 Mm^3 of sand and rock will be removed to lower the existing bed levels (between +0.7m LAT and -10.2 m LAT) to the required depth (refer to Attachment G9).

1 Introduction

Whilst this is the location for the majority of dredging activity (5.7 Mm^3), dredging will also be required for the approach channel (1.1 Mm^3) which is expected to take approximately 8 weeks. The approach channel will be dredged to a depth of -13.5m LAT over a length of 1500m and a channel width of 200m giving a dredge footprint of 300,000 m^2. It will be dredged to a depth of -13.5 m below lowest astronomical tide (LAT). The existing bed levels vary between -6.6 m LAT and -12.1 m LAT. This equates to a volume of approximately 1.1 Mm^3 of sand.

For the purposes of project planning and the EIS it has been assumed that dredging will be carried out within a period of 49 weeks however, this period may vary depending on commercial factors for example. The Dredge Management Plan (DMP) (Attachment G9 of the EIS Supplement) also assumes a 49 week dredging period.

The proposed capital dredging locations are shown in Figure 1-1.

Due to the characteristics of the material to be dredged for the approach channel and swing basin and the presence of pockets of rock, the most technically suitable and cost effective dredging plant is a large or medium cutter suction dredge (CSD) (refer Attachment G9).

1.2.2 Materials Offloading Facility

Dredging may be required to ensure suitable barge and ferry access to the MOF. The volume of dredged material will be approximately 100,000 m^3.

Based on the currently available geotechnical information for the area, the characteristics of the material to be dredged for the MOF may be as follows:

- Soft silts and clay - 50 %;
- Sand and gravels – 40 %;
- Weak rock – 5 %; and
- Hard rock – 5 %.

Based on the assumed likely material, available water depths and the volume of material to be dredged, the dredging will be carried out using a medium sized CSD. The CSD will pump dredged material to an onshore reception lagoon and settlement pond. The most suitable location for such works will be adjacent to the MOF haul road where control of the operation and the potential beneficial reuse of the material will be possible.

The majority of the dredged material is expected to be suitable for engineering re-use, and thus will be used as fill material for the construction of the MOF and laydown area. However, due to the high content of soft clay in the material, it may not be possible to make use of all the material for engineering purposes (i.e. structural fill). This material will therefore remain in the reception lagoon where it will be stabilised and rehabilitated for use as landscaping. Alternatively it may be pumped to the proposed dredge material placement facility at Laird Point.

N W E S

0 750 1500m

Scale: 1:40,000 (A4)
Datum: GDA94

Existing Channels
Proposed Dredging Channel
Dredge Material Placement Facility
LNG Facility Indicative Site Boundary

Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY POTENTIAL CORAL LOSS ASSESSMENT	**LOCATION OF DREDGE FOOTPRINT AND DREDGE MATERIAL PLACEMENT FACILITY**
	Drawn: RG / Approved: JB / Date: 16-11-2009	Figure: **1-1** / Rev:A
	Job No: **4262 6440** /6220 / File No: 42626440-g-2189.wor	A4

1.3 Objectives

The primary objective of this assessment was to provide quantitative data on the soft corals and sponge communities potentially impacted by dredging activities associated with the development of the GLNG Project.

The report provides data on the soft corals and sponge communities found within Port Curtis, adjacent to the proposed capital dredging activities.

1.4 Scope of work

The report presents the following:

- Describe in a quantitative manner the subtidal communities (focussing on the major habitat types encountered);
- Assess the natural variability these ecosystems can tolerate;
- Assess the potential impact of dredging activities on these communities; and
- Present mitigation measures to minimise potential impacts to these communities.

Methods

2.1 Sites

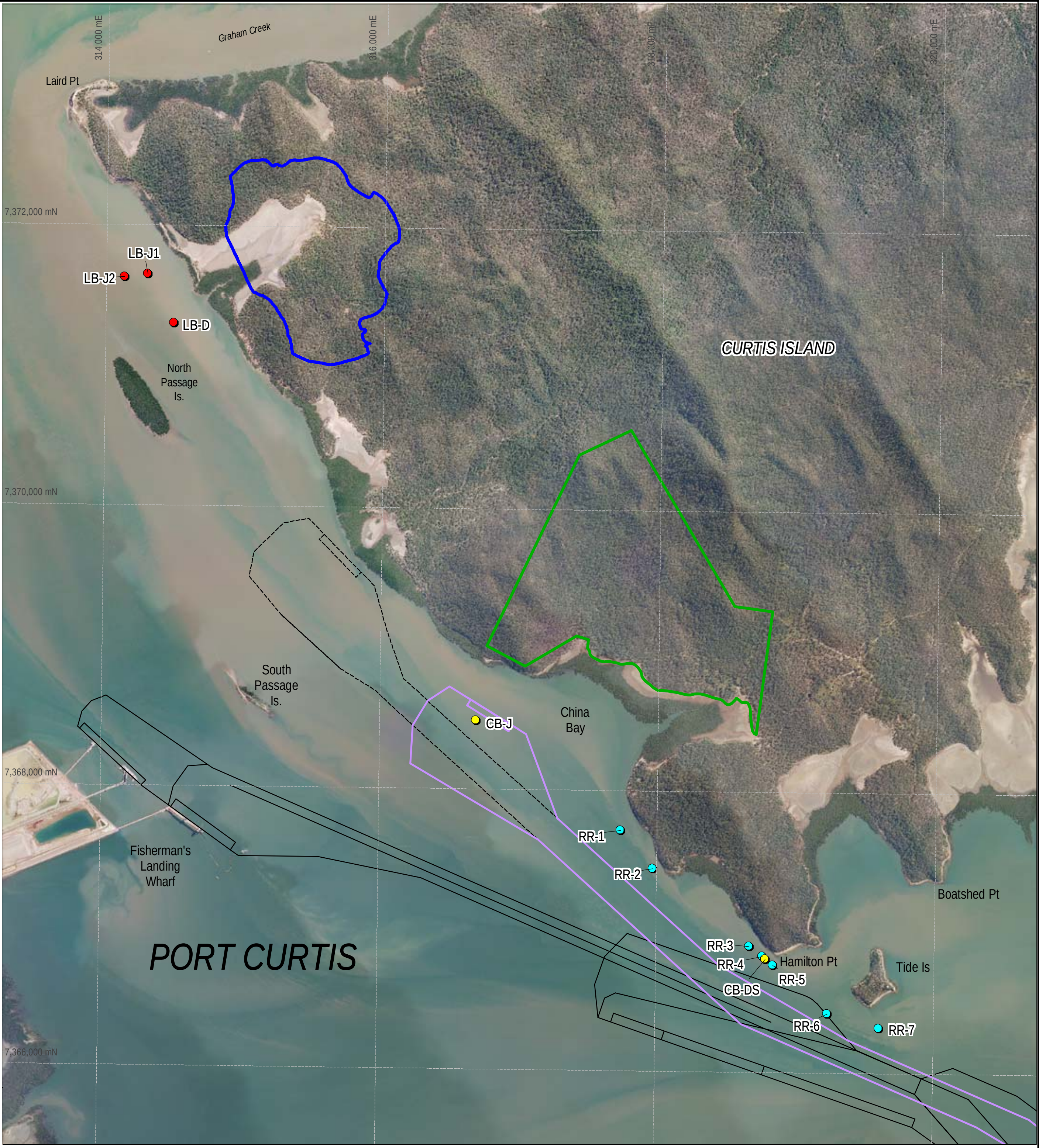
Seven subtidal sites were selected for this survey based upon previous observations of the subtidal communities in the vicinity of the LNG facility. The coordinates[1] of the sites selected are listed in Table 2-1 and the locations are shown in Figure 2-1.

Table 2-1 Subtidal survey Sites

Site	Northing	Easting	Date Surveyed	Underwater Visibility	Water Depth*		
						Gauge	MSL
RR-1	23.79145	151.21111	30/8/09	0 – 10 cm	Shallow	3.5	4.4
					Deep	7.1	8.0
RR-2	23.79392	151.21339	30/8/09	50 cm	Shallow	3.4	3.5
					Deep	7.8	7.9
RR-3	23.79894	151.22017	28/8/09	75 cm	Shallow	4.1	4.8
					Deep	7.6	8.3
RR-4	23.79956	151.22112	28/8/09	75 cm	Shallow	4.0	4.1
					Deep	7.9	8.0
RR-5	23.80016	151.22185	27/8/09	100 cm	Shallow	3.7	4.1
					Deep	8.6	9.0
RR-6	23.80328	151.22568	29/8/09	50 cm	Shallow	3.5	4.4
					Deep	7.4	8.3
RR-7	23.80423	151.22931	30/8/09	50cm	Shallow	3.7	4.5
					Deep	7.7	8.5

* Gauge depth is the recorded depth. MSL depth is depths adjusted for tide to Mean Sea Level (MSL).

[1] All coordinates are based on Geocentric Datum of Australia (GDA) 94



N
W E
S

0 750 1500m

Scale 1:40 000 (A4)
Datum: GDA94

LNG Facility Indicative Site Boundary
Dredge Material Placement Facility Footprint
Existing Channel
Proposed GLNG Channel
Proposed BG Channel

Laird Bay Survey Sites
China Bay Survey Sites
Rocky Reef Survey Sites

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Client	Project	Title
LNG	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY	**SITE MAP SHOWING SURVEY LOCATIONS**
URS	Drawn: LL / Approved: JB / Date: 05-11-2009 Job No: **4262 6440**/6220 / File No: 42626440-g-2073c.wor	Figure: **2-1** / Rev:C / A4

2.2 Data Collection

At each site a GPS position was recorded and notes taken on weather conditions. Divers using self contained underwater breathing apparatus (SCUBA) surveyed the subtidal communities occurring along 50 m transects at seven monitoring sites. Four transects were surveyed at each site; two transects in approximately 7 – 8 m water depth, and two transects in approximately 3 – 4 m water depth. A flexible fibreglass measuring tape was laid along each transect. A diver followed along the transect taking between 50 and 60 digital photographs of the substrate adjacent to the measuring tape. The camera was held at a constant distance of 0.5 m above the seabed during photography. A total of 1,520 photographs were taken.

The data were assessed using the protocols from the Australian Institute of Marine Science (AIMS) Video Transect Analysis System (AVTAS) method (Page *et al.*, 2001). The AVTAS method randomly selects forty video frames per transect, and the substrate underneath five random points in each of the 40 frames is recorded, giving 200 data points per transect. For this survey, 40 digital images from each transect were randomly selected (out of the 50 to 60 taken) and the substrate underneath five random points in each of the 40 frames was recorded. The percentage cover occupied by the different taxa and other substrate types were then calculated for the whole transect using the 200 observations.

Cover categories recorded included soft corals (gorgonians and *Dendronephthya* sp.), *Tubastrea faulkneri*, sponges (branching, clumping and encrusting), macroalgae (red, green and brown), bryozoans (lace corals and other bryozoans), echinoderms (feather stars, sea stars and brittle stars), zoanthids, hydroids and non-living cover (silt, shell grit, rubble, sand, rock) (Refer to Section 3 for further information on each recorded cover category). However in order to follow the scope of this report only the soft corals and sponge communities will be discussed.

A complete data set was collected for all sites except Site RR-1. A dense sediment plume emerging from the intertidal mud flats at China Bay on the ebb tide reduced underwater visibility to less than 5 cm (Plate 2-1). As a result, only two transects were fully surveyed at RR-1 (one deep and one shallow transect, both towards the south east).

Plate 2-1 Ebb tide from China Bay near the RR-1 site

2.3 Data Analysis

For each depth (deep, shallow) at each site, the mean percentage cover and standard error (SE) were calculated for each category, as well as total live cover. The total live cover at each depth at each site was graphed, as was the composition of major taxa.

For site RR-1, the shallow transect not surveyed was excluded. As a result, there are no error bars associated with the data from the shallow transect. The data from the deep transect partially surveyed was reported in percentage terms using the 22 digital photographs available.

Statistical analyses were not undertaken as part of this report. However, if further monitoring is conducted the data is amenable for various analyses (e.g. Analysis of Variance [ANOVA], regression analysis and various multivariate procedures).

Results

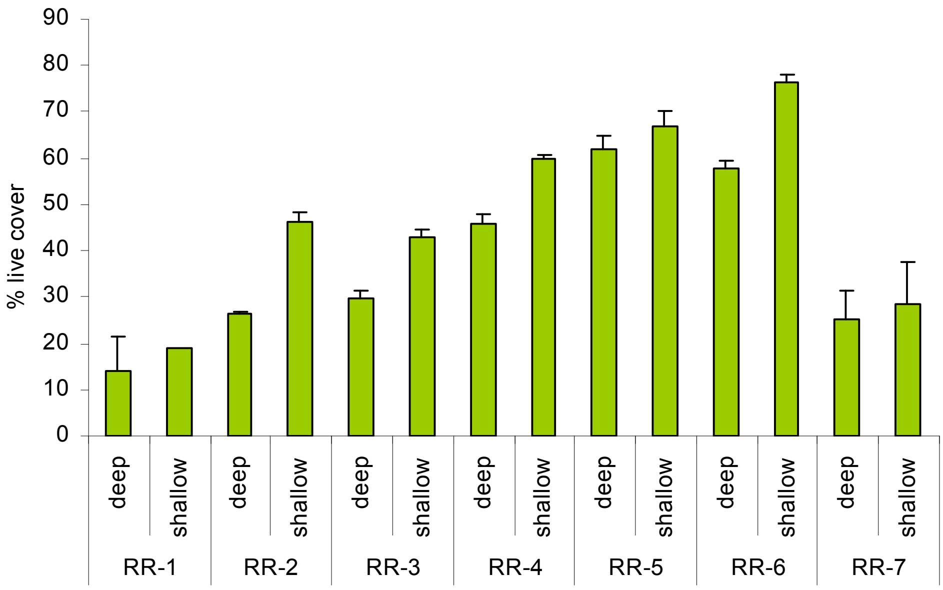
3.1 Overview of benthic communities

Total live cover of benthic communities averaged over all sites and depths was 43.8 ± 3.73 % (mean ± SE), ranging from 16.5 ± 4.69 % at Site RR-1 through to 67.1 ± 5.49 % at Site RR-6.

Total live cover of benthic communities averaged over all shallow sites was 50.8 ± 5.30 %, ranging from 19.0 % at Site RR-1[2] through to 76.5 ± 1.50 % at Site RR-6. Total live cover of benthic communities averaged over all deep sites was 37.3 ± 4.77 %, ranging from 13.9 ± 7.57 % at Site RR-1 through to 61.8 ± 3.25 % at Site RR-5. Figure 4-1 shows the mean (± SE) percentage cover for each depth at each site, and the composition of the major taxa.

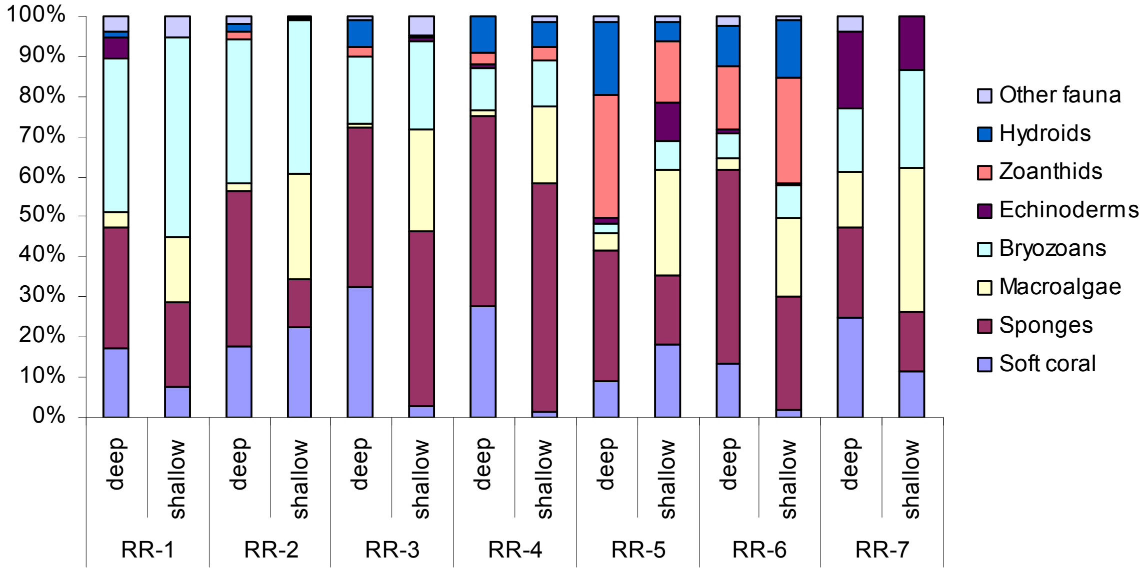
Overall, percentage cover of soft coral was higher at the deeper transects (7.1 ± 1.26 %) than at shallow transects (4.7 ± 1.36 %). Percentage cover of sponges was approximately the same at both depths (14.9 ± 3.04 % on shallow transects, and 14.5 ± 2.40 % on deep transects). There was significantly higher percentage cover of macroalgae and bryozoans on shallow transects (12.2 ± 1.33 % and 8.7 ± 1.33 %, respectively) than on deep transects (1.4 ± 0.38 % and 4.8 ± 0.76 %, respectively). There was no significant difference of percentage cover of either Zoanthid or hydroid between shallow (5.1 ± 2.23 % and 2.7 ± 1.17 %, respectively) and deep (4.3 ± 1.86 % and 3.5 ± 1.15 %, respectively) transects.

Figure 3-1 Mean percentage total live cover (± SE) at subtidal sites (top) and composition of major taxa (bottom) at each site



[2] There is no SE associated with this number as only one transect was surveyed.

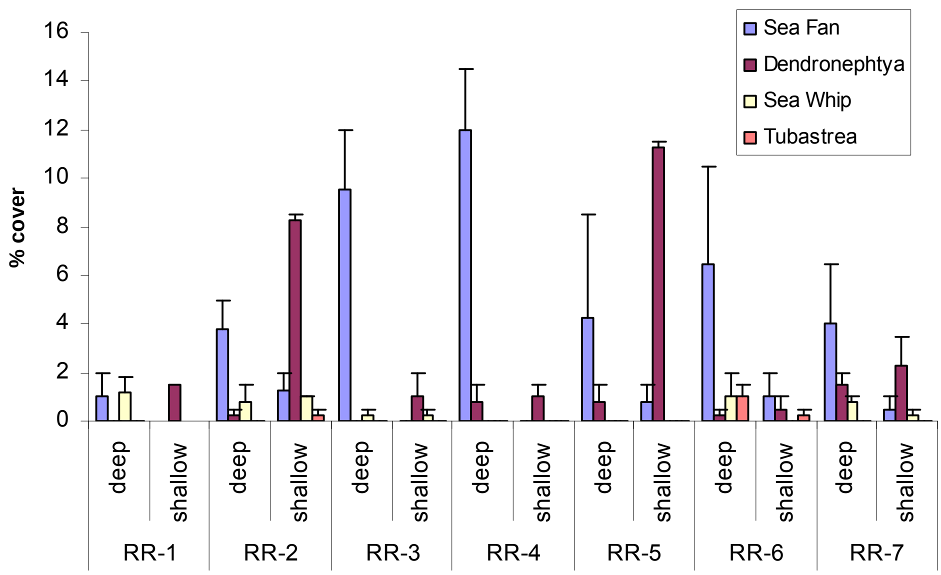
3 Results



3.2 Corals

Figure 4-2 shows the percentage cover of coral at shallow and deep transects for each site. *Tubastrea faulkneri* (Plate 4-1) was found only at sites RR-6 and RR-2 in low densities. Sea fans (Plate 4-2) were primarily found on the deeper transects, while *Dendronephthya* sp. (Plate 4-3) was primarily found on the shallow transects. Sea whips were found at most sites (except RR-4 and RR-5) in low densities. Several sea pens (*Pteroeides* sp.) were recorded and a single colony of black coral (*Antipathes* sp.) was detected at site RR-5 on one of the deep transects.

Figure 3-2 Mean percentage soft coral and Tubastrea faulkneri cover (± SE) at Subtidal Sites



3 Results

Plate 3-1 Tubastrea faulkneri at Site RR-6

Plate 3-2 Sea fan and feather stars at Site RR-5

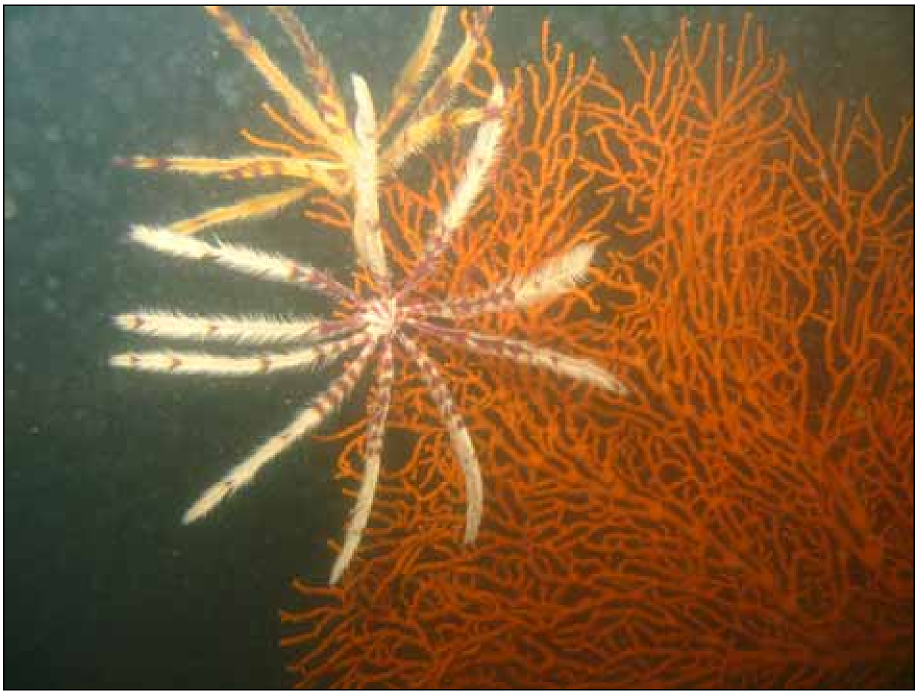
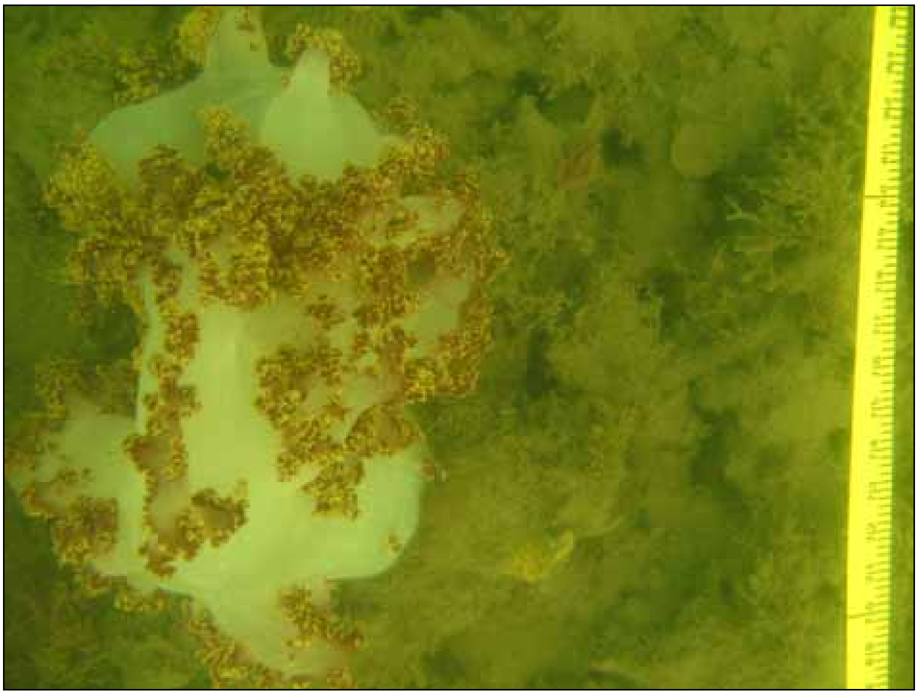


Plate 3-3 Dendronephthya sp. at Site RR-2



3.3 Sponges

Total sponge percentage cover averaged over deep and shallow transects ranged from 4.1 ± 1.90 % at Site RR-1 through to 27.8 ± 4.07 % at Site RR-4. Sponges were grouped and recorded according to morphological characteristics. Branching sponges were more abundant in the shallow transects, while massive and encrusting sponges were more abundant on the deep transects. Figure 4-3 shows the distribution of sponge types at shallow and deep transects for each site. Plate 4-4 shows examples of 'massive' and 'branching' type sponges and Plate 4-5 shows examples of 'encrusting' type sponges.

3 Results

Figure 3-3 Mean percentage sponge cover (± SE) at Subtidal Sites

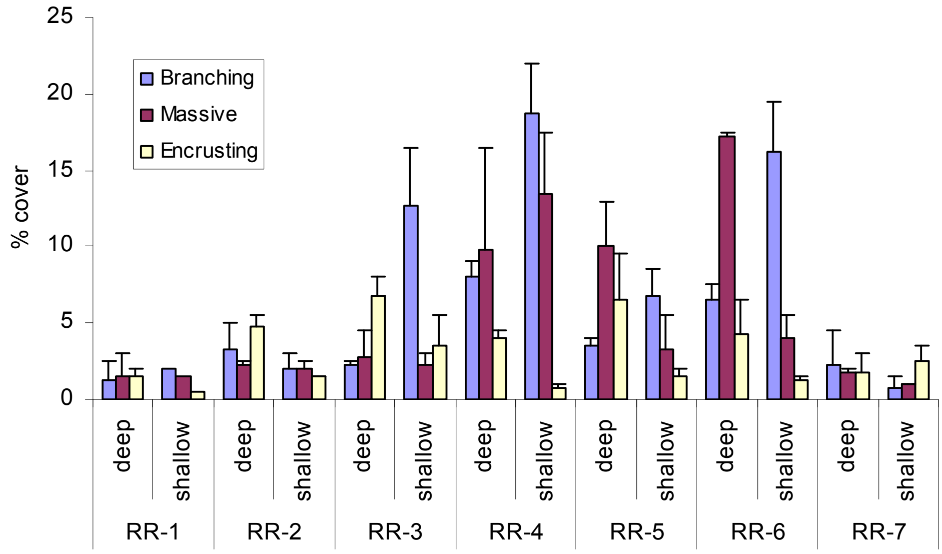
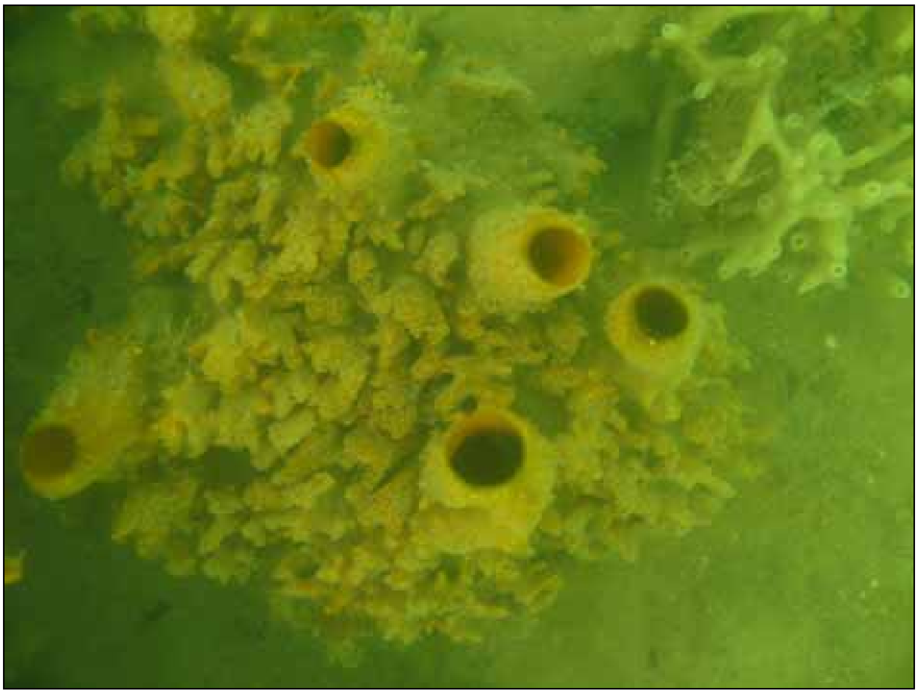


Plate 3-4 Massive' type (left) and 'branching' type sponge (upper right) at Site RR-4



3 Results

Plate 3-5 Encrusting' type sponges at Site RR-4

Discussion

Soft corals and sponge communities in shallow near shore waters grow in habitats that are naturally affected by freshwater runoff and sediment re-suspension. Depth, wave exposure, slope, flow, sediment levels and interactions between these factors affect soft coral abundances and assemblages (Fabricius & De'ath, 1996; Fabricius & Alderslade, 2001). Soft corals located on the narrow coastal margin are particularly prone to land-based inputs and water-based activities (Gabric & Bell, 1993; Vermaat *et. al*., 1996; Short & Wyllie-Echeverria, 1996; Livingston *et. al*., 1998).

Dredging activities usually result in elevated resuspended sediments and turbidity levels for a period of time. Enhanced levels of suspended sediment and turbidity can potentially change the condition of reef communities in a number of ways (Anthony & Fabricius, 2000; Morelock *et. al*., 2001, Acevedo & Morelock, 1988 A decrease in the clarity of the water column is recognised as one of the most important factors limiting reef development (Loya, 1976; Acevedo *et. al*., 1989; Rogers, 1990; Hallock & Schagler, 1986; Burt *et. al.,* 1995). For instance, loss of reef structure due to in-filling by sediment may lead to a reduction in numbers of herbivorous fish and a subsequent increase in macroalgae (Williams, 2001; Hallock & Schagler, 1986; Acevedo & Morelock, 1988).

The soft coral and sponge communities surveyed are adjacent to the proposed areas of capital dredging and may be potentially impacted by:

- Elevated levels of TSS and turbidity; and
- Decreased water quality.

4.1 Soft Corals

Octocorals are a diverse group of reef inhabiting organisms on Indo-Pacific coral reefs (Fabricius & Alderslade, 2001). There are three scientific orders in the Subclass Octocorallia: the Order Alcyonacea, which contains all species commonly known as soft corals and sea fans; the Order Helioporacea, (blue coral); and the Order Pennatulacea (sea pens).

The great majority of octocorals found on the Great Barrier Reef (GBR) belong to the Order Alcyonacea (the true 'soft corals' and 'gorgonians'). Within this order, about 100 genera in 23 families have been described from shallow waters of the Indo-Pacific to date. In comparison, the Pennatulacea (sea pens) and Helioporacea (blue coral) play a minor role in the octocoral fauna of shallow coral reefs. In sea pens, nine genera in five families are presently known from shallow waters of the tropical and subtropical Indo-Pacific, where they tend to live in soft bottom habitats (Alderslade & Fabricius, 2008). The blue coral is represented by a single species in the Indo-Pacific.

Relatively few detailed octocoral studies exist (e.g. from the GBR and other parts of Australia, New Guinea, New Caledonia, Micronesia, Japan, southeastern Africa and the Red Sea), and there are still major gaps in the understanding of octocoral biogeography (Alderslade & Fabricius, 2008; Fautin *et. al*., 2004). Furthermore, the number of shallow water Indo-Pacific octocoral species is unknown, as many species still await taxonomic description and many genera are in urgent need for revision. The only systematic taxonomic inventory of Indo-Pacific octocorals is from Palau in Micronesia, where 150 species have been recorded. On the GBR, the species number might be similar, but verification of such an estimate will remain impossible until taxonomic research advances (Alderslade & Fabricius, 2008; Stokes *et. al*., 2000).

Soft corals have clonal life histories but relatively few studies have examined demographic aspects of their populations worldwide compared to aclonal or clonal plants (Hughes & Cancino, 1985; Tanner, 2001; Bastidas *et. al*., 2003). The great capacity of clonal species to survive and recover from partial mortality, and a long life-span confer on them many advantages over aclonal organisms (Hughes & Cancino, 1985; Jackson, 1985; Bastidas *et. al*., 2003). Previous studies on offshore reefs of the GBR revealed a large variability in life histories (Dinesen, 1985). Studies of soft corals are lacking from inshore reefs where members of the Alcyoniina and Stolonifera form large aggregations, locally occupying up to 80 % of the total coral cover in shallow waters (Bastidas *et. al.,* 2004; Fabricius & De'ath, 1996).

4.2 Sponges

Marine sponges are an essential and highly diverse component of marine benthic communities, ranging from the euryhaline estuarine, to intertidal, to the deep-sea (Hooper and Van Soest, 2002). It is estimated that world wide there are about 15,000 species of sponge, of which 7,000 are described (Hooper and Weidenmayer, 1994; Hooper and van Soest, 2002). Approximately 1,400 species in 313 genera and 83 families (Hooper and Wiedenmayer, 1994; Australian Fauna Directory, 2005) have been described from the Australian region, although over 4,000 morphospecies have already been collected.

Few studies have looked at sponges in tropical Australian ecosystems. Hooper and Kennedy (2002) described sponges from inshore areas of the Sunshine Coast, Queensland, and found a rich fauna of 247 species of marine sponges (Porifera) in 97 genera, 44 families and 14 orders, with 51 % of species not previously recorded elsewhere from the Indo-west Pacific. Sixty per cent of species were 'unique' or 'apparent endemics' (i.e. they were recorded from only one station.) and only 19 % of species co-occurred in the adjacent Moreton Bay region.

Fromont *et. al*., (2007) recorded 150 species and 2,596 individual sponges in 43 subtidal stations in the Dampier Archipelago, Western Australia. Many of the species (48 %) were 'unique' or 'apparent endemics'. A further 13 % were found at two stations. Modelling of the total species diversity of the area indicated that they only captured 56–80 % of the sponge diversity. Modelled predictions suggest that total diversity for the Dampier Archipelago lies between 245 and 346 species compared to the number found in their study (150 species).

Evidence suggests that tropical sponge faunas can be extremely speciose (see Fromont, 2003 and references therein). Sponges frequently form spatially heterogeneous assemblages with patchy distributions, often containing high numbers of species not found in adjacent communities (e.g. Hooper and Kennedy, 2002), sometimes with as little as 15 % similarity in species composition between geographically adjacent reef sites.

From the data available on sponge larval biology, it appears that dispersal capabilities of propagules are limited, mostly not exceeding 72 hr in the water column before settlement (Maldonado and Young, 1996; Uriz *et. al.*, 1998) (for an exception see Vacelet, 1981), and one might predict high genetic structuring of sponge populations.

Sponges are influenced by a range of human activities, particularly trawling and dredging (Dayton *et. al.,* 1995; Wassenberg *et. al.,* 2002). However, species loss is difficult to determine because sponge patterns of occurrence are so poorly understood.

Beneficial effects of sponges on coral reef health and growth have been demonstrated to include increased coral survival, reef regeneration, water column clearing, nutrient recycling, primary productivity, and food for sponge-feeding fishes, starfish, and turtles. Many sponges harbor highly diverse communities of symbiotic animals, including annelids, arthropods, fishes, and molluscs (Wulff, 2001).

Diversity of sponges has been shown to increase with increasing depth (Liddell & Olhorst, 1987; Roberts & Davis, 1996; Bell & Barnes, 2000), and to be higher at sites with slight to moderate water flow and moderate to high sedimentation, compared to sites with fast current flow and low sedimentation (Bell & Barnes, 2000).

In addition to the opportunistic sponge-feeders, which only eat sponges when edible species are made available by a disturbance, are sponge specialists, which depend on many sponge species being available at all times. Sponge specialists include hawksbill turtles, which focus their attention on a variety of species within particular orders of sponges (Meylan, 1990; van Dam & Diez, 1997) and angelfishes, which may require even broader taxonomic representation of sponges (Randall & Hartman, 1968; Wulff, 1994).

4.3 Water Quality Modelling

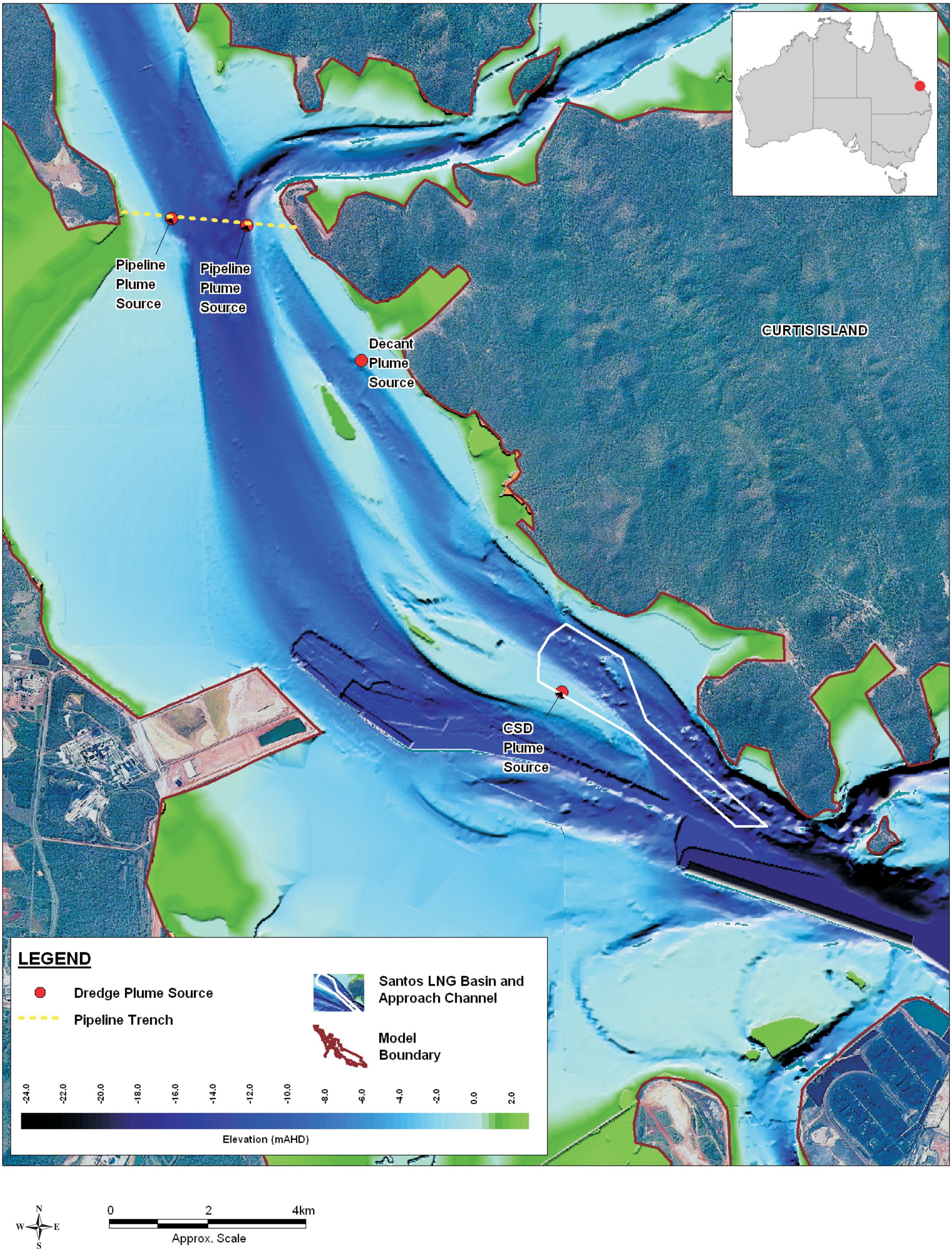
BMT WBM (2009) was commissioned to undertake additional dredge plume modelling in support of the GLNG EIS Supplement. This modelling was incorporated into the *Port Curtis Water Quality Studies* report prepared for the GLNG EIS Supplement (refer to Attachment G5, Appendix A of the EIS Supplement) along with other information collected on measured sedimentation rates within Port Curtis.

A review of TSS in eastern Port Curtis is included within (refer to Attachment G5, Appendix A of the EIS Supplement). It reports background TSS levels ranging between 2 and 116 mg/L, with a median range of between 30 and 47 mg/L. The following conclusions were drawn:

- Turbidity and TSS concentrations are moderate and also highly variable throughout the eastern side of Port Curtis;
- Turbidity increases with depth and tidal velocity, most likely due to bottom sediment re-suspension; and
- Primary variations in spatial distribution and nature of turbidity and TSS appear to be controlled by tidal stage and stream flow of major rivers flowing into the harbour.

Sediment traps were installed at a number of locations as shown in Figure 5-1 of Attachment G5 of the EIS Supplement. The nearest sediment trap to the subtidal sites is 'Sediment Trap 7', located in the vicinity of the proposed swing basin in China Bay. The sediment mass accumulation rate (MAR) at this location was calculated as 16.07 ± 1.67 (standard error) mg dry wt cm^{-2} day^{-1}.

The 'plume source locations' are shown in Figure 5-1. A single point within the proposed swing basin was used to model the sediment plume created by the CSD. All dredge plume simulations were modelled for a one (1) month period from the 4/2/2009 to the 4/3/2009 using measured tidal and wind boundary conditions. Model Calibration and boundary conditions are described in Attachment G5, Appendix A of the EIS Supplement. It should be noted that the sediment plume modelled by WBM in the Attachment G5, Appendix A of the EIS Supplement does not account for all locations of the dredging activities, as the dredging will occur along the approach channel to China Bay, adjacent to the subtidal communities (at least for a while).



Source: BMT WBM Figure 2.3 (Nov. 2009)

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT MARINE ECOLOGY POTENTIAL CORAL LOSS ASSESSMENT	**PLUME SOURCE LOCATIONS**
	Drawn: LL · Approved: JB · Date: 13-11-2009	Figure: **4-1** · Rev. A
	Job No.: **4262 6440** /6220 · File No. 42626440-g-2188.cdr	A4

4 Discussion

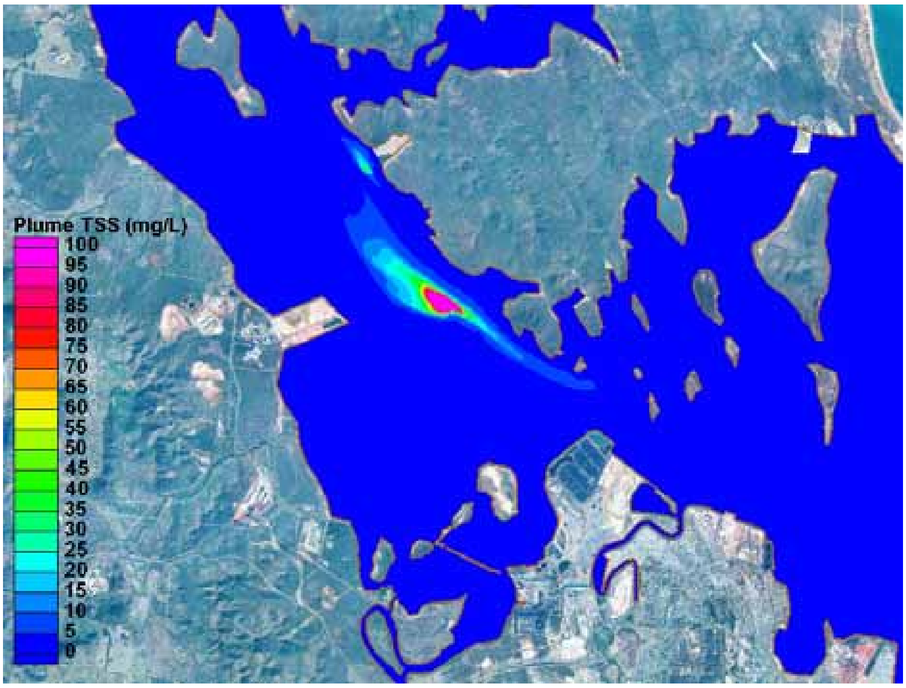
4.3.1 Results

The “dredge plume” is defined as the quantity of Total Suspended Solids (TSS) which is in the water column due to dredging, and is above the natural background levels for that location and time. TSS concentrations and plume sediment deposition rates were modelled to predict the maximum and 10 % concentrations that would be produced during dredging activities. In addition time series plots of the predicted TSS concentrations and deposition rates were produced at nine sensitive receptor sites (Table 4-1 and Table 4-2). The nearest sensitive receptor site is located at Hamilton Point (No. 9).

TSS levels

Figure 4-1 shows the predicted maximum TSS concentrations for dredging operations using the CSD. As discussed earlier these values represent the potential maximum values and do not represent the duration of impact. They should therefore be interpreted as an envelope for potential dredging impact. The 10 % exceedance predictions for TSS concentration shown in Figure 4-2 provide more information on the potential duration of impact. The data shown in this figure indicates that for 10 % of the time TSS concentrations will exceed 100 mg/L at the dredger head and be in the order of 30 mg/L in the immediate vicinity of the dredger. These concentrations diminish to approximately 5 mg/L in relatively close proximity to the proposed dredging channel. The results shown in Figure 4-3 indicate that during Neap Tide the concentration will exceed 100 mg/L at the dredge head but that the predicted dredge plume will be confined to the immediate vicinity of the dredger. The results shown in Figure 5-6 indicate that during Spring tide TSS concentrations are unlikely to exceed 20 mg/L in area surrounding the dredger.

Figure 4-2 CSD dredging scenario - maximum plume TSS concentration



4 Discussion

Figure 4-3 CSD dredging scenario - 90th percentile TSS concentration

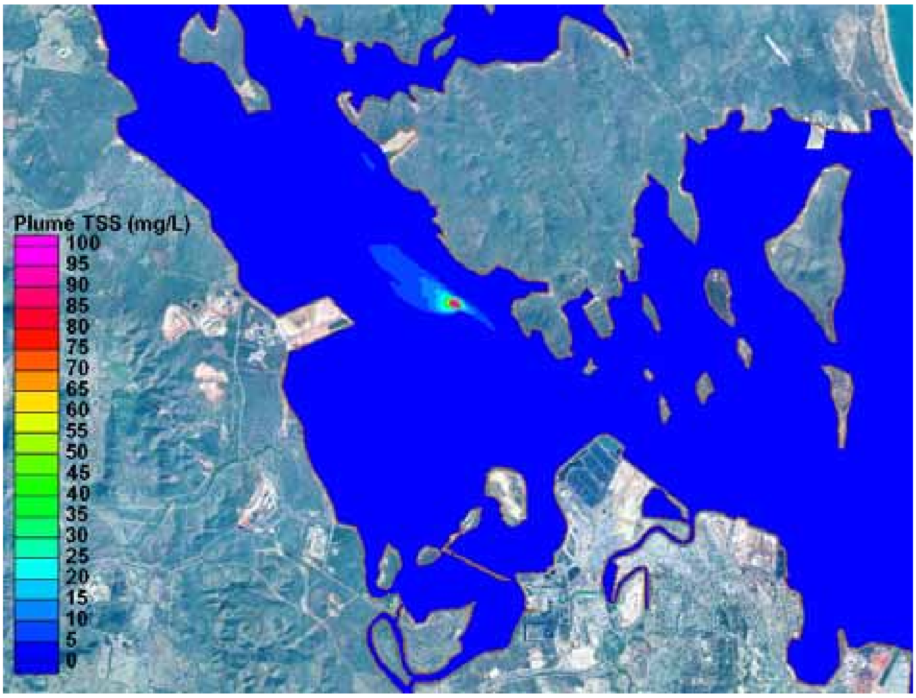


Figure 4-4 CSD dredging scenario – Plume snapshot at 01:00 on 18/02/2009 (Neap Tide)

4 Discussion

Figure 4-5 CSD dredging scenario – Plume snapshot at 09:00 on 26/02/2009 (Spring Tide)

Summary statistics for the TSS predicted concentrations produced by the CSD at the sensitive receptor locations are provided in Table 4-1.

Table 4-1 Summary statistics for predicted TSS concentrations generated by the CSD at sensitive receptor locations

TSS (mg/L)		Sensitive Receptor Locations								
		PT1	PT1	PT3	PT4	PT5	PT6	PT7	PT8	PT9
CSD	50th Percentile	0	0	1	1	2	2	1	1	1
	80tth Percentile	0	0	2	2	2	5	2	1	2
	90th Percentile	1	1	2	2	3	8	2	1	2
	95th Percentile	1	1	2	2	3	11	2	1	3
	Maximum	1	1	3	3	6	38	3	2	4

Doorn-Groen and Foster (2007) compiled data from a number of projects in Singapore where coral health, sediment plumes and TSS were measured. Using this data they developed impact severity matrices for TSS (Table 4-3) that they suggest is applicable to turbid, reefal environments.

4 Discussion

Table 4-2 Impact severity matrix for suspended sediments on corals in environments with high background concentrations (Reproduced from Doorn-Groen and Foster, 2007)

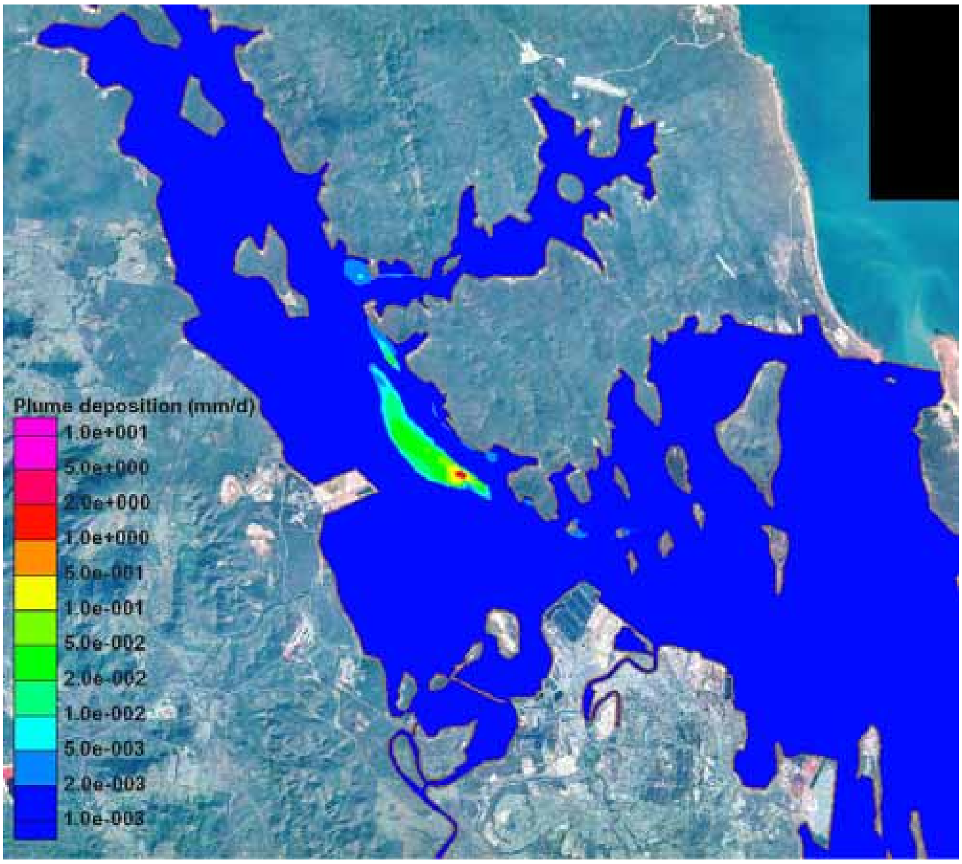
Severity	Definition (excess concentration)
No Impact	• Excess Suspended Sediment Concentration > 5 mg/L for less than 5 % of the time.
Slight Impact	• Excess Suspended Sediment Concentration > 5 mg/L for less than 20 % of the time. • Excess Suspended Sediment Concentration > 10 mg/L for less than 5 % of the time.
Minor Impact	• Excess Suspended Sediment Concentration > 5 mg/L for more than 20 % of the time • Excess Suspended Sediment Concentration > 10 mg/L for less than 20 % of the time
Moderate Impact	• Excess Suspended Sediment Concentration > 10 mg/L for more than 20 % of the time • Excess Suspended Sediment Concentration > 25 mg/L for more than 5 % of the time
Major Impact	• Excess Suspended Sediment Concentration > 25 mg/L for more than 20 % of the time • Excess Suspended Sediment Concentration > 100 mg/L for more than 1 % of the time

Sediment Deposition

The deposition modelling results indicate that dredging activity has the potential to contribute to increased deposition rates within Port Curtis. Increased rates in the order of 1mm/d are anticipated at the dredge head and 0.1 mm/d in close proximity to the dredger (Figure 4-5).

4 Discussion

Figure 4-6 CSD with 50mg/L decant - average plume deposition rate



Increased rates in the order of 0.02 mm/d are predicted in the channel between the Passage Islands and Curtis Island which represents a 4% increase on background deposition rates (Table 4-3).

Table 4-3 Predicted deposition rates from CSD

Sensitive Receptor Site	PT1	PT2	PT3	PT4	PT5	PT6	PT7	PT8	PT9
Deposition (mm/day)	0.00	0.0089	0.0037	0.00071	0.0175	0.0560	0.0012	0.00014	0.00
Mass Accumulation Rate (g/cm^2/d)	0.0	0.0004	0.00017	0.000032	0.00079	0.0025	0.000053	0.000006	0.00
mass accumulation (mg/cm^2/d)	0.0	0.399	0.167	0.032	0.789	2.52	0.053	0.0065	0.00
Mass Accumulation Rate (g/cm^2/yr)	0.0	0.146	0.061	0.012	0.288	0.92	0.020	0.0024	0.00

In order to assess the depositional impacts of the proposed dredging activity on sensitive receptors time series graphs of plume deposition were produced for each receptor site. These graphs are provided in Attachment G5 (Appendix B of Appendix A) of the EIS Supplement. Average sediment deposition rates were derived at each site based on the final 2-weeks of the 1 month simulation, where suspended sediment mass levels were seen to have reached a dynamic saturation level. The average deposition rates predicted at each sensitive receptor location for the CSD are provided in Table 4-2.

It should be noted that this is likely to underestimate the impacts upon the soft corals and sponge communities as the 'plume source' will be much closer at times than has been modelled.

As mentioned above, Doorn-Groen and Foster (2007) compiled data from a number of projects in Singapore where coral health, sediment plumes, TSS and sediment deposition were measured. Using this data they developed impact severity matrices for sediment deposition (Table 4-4) that they suggest is applicable to turbid, reefal environments.

Table 4-4 Impact severity matrix for sedimentation impact on corals (Reproduced from Doorn-Groen and Foster 2007)

Severity	Definition (excess concentration)
No Impact	• Excess Suspended Sediment Concentration > 5 mg/L for less than 5% of the time.
Slight Impact	• Excess Suspended Sediment Concentration > 5 mg/L for less than 20% of the time. • Excess Suspended Sediment Concentration > 10 mg/L for less than 5% of the time.
Minor Impact	• Excess Suspended Sediment Concentration > 5 mg/L for more than 20% of the time • Excess Suspended Sediment Concentration > 10 mg/L for less than 20% of the time
Moderate Impact	• Excess Suspended Sediment Concentration > 10 mg/L for more than 20% of the time • Excess Suspended Sediment Concentration > 25 mg/L for more than 5% of the time
Major Impact	• Excess Suspended Sediment Concentration > 25 mg/L for more than 20% of the time • Excess Suspended Sediment Concentration > 100 mg/L for more than 1% of the time

Table 4-5 Impact severity matrix for sedimentation impact on corals (Reproduced from Doorn-Groen and Foster, 2007)

Severity	Definition (excess sedimentation)	
No Impact	Sedimentation < 0.05 kg/m^2/day	(<1.7 mm/14day)
Slight Impact	Sedimentation < 0.1 kg/ m^2/day	(<3.5 mm/14day)
Minor Impact	Sedimentation < 0.2 kg/ m^2/day	(<7.0 mm/14day)
Moderate Impact	Sedimentation < 0.5 kg/ m^2/day	(<17.5 mm/14day)
Major Impact	Sedimentation > 0.5 kg/ m^2/day	(>17.5 mm/14day)

In Queensland, there have been a number of dredging projects where coral communities have potentially been at risk. The Nelly Bay project implemented a hierarchy of triggers, including discharge monitoring, receiving waters monitoring, and coral condition monitoring, to determine whether it was safe for dredging to proceed.

4 Discussion

During dredging at Hay Point, a turbidity threshold for corals of 45 NTU (100 mg/L) above background levels was set, which was not to be exceeded for periods of greater than six hours (Trimarchi & Keane, 2007). A condition attached to the Environmental Management Plan (EMP) was that coral mortality should not exceed 5 %.

The triggers/thresholds used in the Nelly Bay, Hay Point and Singapore projects described above provide a basis for ongoing monitoring and impact analysis.

5

Potential impacts and mitigation measures

5.1 Potential impacts

Elevated levels of TSS and associated sedimentation may potentially impact corals and other taxa in the following ways:

- Reducing coral performance through redirecting energy towards sediment removal (Stafford-Smith & Ormond, 1992);
- Smothering and burial (Fabricius & Wolanski, 2000);
- Abrasion of soft tissues (Stafford-Smith, 1993);
- Inhibiting larval settlement (Gilmour, 1999);
- Interference with respiration and photosynthesis (Peters & Pilson, 1985); and
- Modified exchange and/or supply of nutrients and other chemicals (Woolfe & Larcombe, 1999).

Modelling results indicate that the potential impacts of dredging on subtidal communities are anticipated to be low. It should be noted however that modelling results are based on the dredging within the swing basin. Whilst this is the location for the dredging activity (5.7 million of m^3), dredging will also be required for the approach channel (1.1 million of m^3) which will require positioning of the CSD in closer proximity to the soft coral communities for a period of approximately 8 weeks. During this period the potential impacts on soft coral communities are anticipated to be low to medium. Capital dredging of the swing basin (5.7 $Mm^{3)}$ is expected to take approximately 41 weeks. Potential impacts to adjacent subtidal communities from elevated TSS are expected to be low.

However, very few studies have been conducted on the potential impacts of sedimentation on the communities described in this report. Most previous work has focussed on zooxanthellate[3] hard corals, whereas the species found in this survey are azooxanthellate (i.e. not dependent on light), and with the exception of *Tubastrea faulkneri*, are all soft corals. While all the coral species found in this survey have some ability to remove sediments using their polyps, there is no data available on the rates of removal or the amount of sediment deposition likely to cause partial or total mortality.

A wide range of responses to sedimentation impacts have been reported for corals and other taxa. Most of the experimental approaches have been limited by the relatively short time corals have been exposed to sedimentation. This short time frame is suitable to detect acute effects, but doesn't provide much information on the chronic effects, which may be expected if dredging is to continue over many months. The following examples highlight the uncertainties surrounding the prediction of potential impacts.

Pastorok and Bilyard (1985) suggested that sedimentation rates of 1-10 mg cm^{-2} d^{-1} caused slight effects on reefs, 10-50 mg cm^{-2} d^{-1} caused moderate to severe effects and greater than 50 mg cm^{-2} d^{-1} resulted in catastrophic effects. It should be noted that these thresholds were based upon their results from very dry areas or limestone coasts with minimal surface run-off. However, Anthony (2000) has shown that individual corals are attuned to their ambient conditions and a coral on a turbid fringing reef will have a far greater tolerance to sediments than exactly the same species on outer shelf reefs in clear water.

Hopley *et. al*., (1990) reported on sediment impacts on the near-shore, turbid Cape Tribulation fringing reefs as a result of road construction. They found that suspended sediment levels of 100 mg/L were generally at the upper end of the ambient TSS regime, although they reported levels exceeding 1,000 mg/L in some fringing reef areas during periods of heavy rain. Based on these results, and other data showing naturally high TSS levels for inshore reefs around Magnetic Island, Hopley and van Woesik

[3] Zooxanthellate corals contain symbiotic algae which provide energy resources to the coral through photosynthesis.

proposed maximum TSS and sedimentation rates for corals potentially impacted by dredging at Nelly Bay, Magnetic Island (Table 5-1).

Table 5-1 Suspended sediment and settlement rate limits for corals (Source: Hopley *et. al*., 1990)

	Time period	Rate of sediment settlement (mg/L)	Suspended sediment limit (mg/cm²/day)
Absolute	-	1500	200
Short term	Up to 2 tidal cycles	1000	150
Medium term	Up to 20 days	120	120
Long term	Beyond 20 days	75	80

Tomascik & Sander (1985) found that growth rates (in terms of linear extension) of *Montastrea annularis* exhibited high correlation with a number of water quality variables. Concentration of suspended particulate matter was found to be the best univariate estimator of *M. annularis* skeletal extension rates. This is reflected in the following empirical relationship:

$$\log Y = -0.638 \log SPM + 0.760$$

where: Y = linear extension of the reef building coral *M. annularis* (cm/yr)

SPM = suspended particulate matter concentration.

These results suggest that suspended particulate matter may be an energy source for reef corals, increasing growth up to a certain maximum concentration. After this, reduction of growth occurs due to smothering, reduced light levels, and reduced zooxanthellae photosynthesis (Tomascik & Sander, 1985).

Hawker and Connell (1991) used the Tomascik and Sander (1985) equation to derive long-term tolerances of corals for various parameters below which minimal disruption to coral reef communities should occur. On the basis of concentrations causing a 20 % decrease in growth rate, the maximum tolerance level of corals is a 28 % increase over the ambient concentration of suspended material. Using this equation and the ambient TSS concentrations measured by Wolanski *et. al*., (1981) at Keeper Reef in Australia, Hawker and Connell (1991) estimated a TSS tolerance level for corals at 3.85 mg/L (i.e. 3 mg/L x 1.28 = 3.85 mg/L). It is important to note that the authors considered this estimate to be preliminary and tentative due to the limited data on ambient TSS and coral species effects. Synergistic or additive deleterious effects from other contaminants are possible, but difficult to quantify.

A number of studies have investigated sedimentation impacts upon zooxanthellate corals. Rice and Hunter (1992) found that a number of species from patch reefs in turbid conditions off the Florida coast showed no significant impacts after being subjected to TSS levels of 150 – 200 mg/L for 20 days. A review by Rogers (1990) reported that deposition rates of greater than 10 mg cm^{-2} d^{-1} could be considered “chronic” and ‘high’ and that a reef receiving 15 mg cm^{-2} d^{-1} had fewer species, and less overall live cover than a nearby reef receiving less deposition. Rogers (1990) also noted that sediments are less likely to cause a problem when there are strong currents present.

Fabricius and Wolanski (2000) conducted an experiment investigating the effects of fine estuarine mud upon coral reef organisms. In offshore waters, flocculation was minor with aggregate sizes of approximately 50 µm. They found that a coral (*Acropora* sp.) and coral-inhabiting barnacles (subfamily

5 Potential impacts and mitigation measures

Pyrgomatidae) were able to clean themselves from small settling aggregates at low siltation (<0·5 mg cm^{-2}), but struggled and produced mucus only at high siltation (4–5 mg cm^{-2}). In near-shore waters, flocculation resulted in aggregates between 200-2000 μm diameters, resulting in the death of the barnacles within one hour.

Another experimental study (Weber *et. al*., 2006) exposed a scleractinian coral to various regimes of sedimentation. They found that silt-sized and nutrient-rich sediments can stress corals after short exposure, while sandy sediments or nutrient-poor silts affect corals to a lesser extent.

The response of the hexactinellid glass sponges *Rhabdocalyptus dawsoni* and *Aphrocallistes vastus* to increased sediment loads was investigated in laboratory experiments by Tompkins-MacDonald and Leys (2008). They found that the glass sponge conduction system generates arrest of the feeding current that prevent uptake of small amounts of sediment, and that each species has different threshold sensitivities. However, ongoing exposure to sediment can clog the filtration apparatus. Fine sediment (<25 μm) caused immediate arrests in *R. dawsoni* and *A. vastus*, but with a higher stimulus threshold in *A. vastus.* Large amounts of sediment triggered repeated arrests in both species, and prolonged exposure to sediment (over 4 h) caused a gradual reduction in pumping, with recovery taking up to 25 h.

5.1.1 Summary

According to the predicted TSS levels and sedimentation values and based on Doorn-Groen and Foster (2007) matrice (Table 4-2 and Table 4-5), a range of impacts were derived. As mentioned earlier these values represent the potential values and do not represent the duration of impact. Hence, the quantification of the expected potential impacts being based on the results of the predicted TSS levels and sedimentation should therefore be interpreted as an envelope for potential dredging impact.

Table 5-2 Estimated envelope for potential impact of TSS levels

Location	Duration	Predicted TSS levels	Potential impacts
Dredger head	10% of the time	Exceeds 100 mg/L	Major impact
Immediate vicinity of dredger	na	~ 30 mg/L	Moderate impact
Relatively close proximity to the proposed dredging channel	na	5 mg/L	Minor impact
Dredge head	Neap tide	Exceeds 100 mg/L	Major impact confined to the immediate vicinity of the dredger
Vicinity of the dredge head	Spring tide	~ 20 mg/L	Moderate impact

Table 5-3 Estimated envelope for potential impact of sedimentation

Location	Predicted sedimentation	Potential impacts
Dredge head	1 mm/day	Major impact
Proximity of dredge	0.1 mm/day	Slight impact

5 Potential impacts and mitigation measures

Location	Predicted sedimentation	Potential impacts
Channel between Passage Islands and Curtis Island	0.02 mm/day	No impact

5.2 Mitigation Measures

The dredging will release fine sediment into suspension in the water column. Plume dispersion studies carried out in the EIS and EIS supplementary indicate that such inputs may, if not appropriately controlled, have a significant impact on intertidal communities. Mitigation will involve selecting and planning dredging and discharge activities to maintain losses of suspended solids to an acceptable level. This will include appropriate consideration of dredging technique and day to day methodology. The following mitigation measures to minimize the loss of soft corals and sponges are detailed in the Dredge Management Plan (Attachment G9 of Supplement GLNG EIS):

- Implementation of a suspended solids management strategy to control losses of suspended solids below agreed thresholds;
- Implementation of ballast water management strategy and risk assessment to avoid introduction of marine pests through ballast water of dredging vessels and associated plant. Refer to the Marine Facilities Environmental Management Plan (Attachment B4);
- Minimise dredge footprint;
- Dredging without overflow;
- Dredging a different material;
- Reducing the duration of dredging and; and
- Dredging at a certain state of the tide.

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Conclusion and Recommendations

6.1 Conclusion

From the information presented above, it is likely there will be potential impacts from capital dredging due to elevated levels of TSS and sediment deposition on adjacent soft coral and sponge communities around Hamilton Point. Dredging activities for the approach channel is likely to cause the greatest level of impact to adjacent soft corals through deposition of sediment and elevated TSS concentrations. Predictions of the extent of potential impacts to soft coral and sponge communities resulting from the dredging activities are based on the outcomes of the sediment plume modelling, rates of deposition, location of the dredging footprint and dredging activities detailed in the Dredge Management Plan (Attachment G9 of the EIS Supplement). It is likely that estimates of potential impact may be underestimated as the 'plume source' will be much closer during dredging of the approach channel than was modelled at the time.

Results from plume modelling suggest the sediment plume created by dredging activities spreads gradually but continuously decays with distance from the dredge. Soft corals directly adjacent to the dredge will incur the greatest potential impact during dredging of the approach channel where for 10% of the time TSS concentrations will be in excess of 100mg/L at the dredge head and 30 mg/L in the immediate vicinity of the dredger. TSS concentration during neap tide dredging will exceed 100 mg/L at the dredge head but that the predicted dredge plume will be confined to the immediate vicinity of the dredger whereas TSS concentrations during spring tide are unlikely to exceed 20 mg/L in the area surrounding the dredger. Increased sediment deposition rates in the order of 0.02 mm/d are predicted in the channel between the Passage Islands and Curtis Island which represents a 4% increase on background deposition rates.

The review of the scientific literature shows that there is a wide range of TSS and sediment deposition rates that have been reported to cause impacts (mostly on hard corals). The potential impacts to soft coral and sponge communities from elevated TSS concentrations from dredging are not well understood. The ability of soft corals and sponges to recover following an 8 week period of elevated TSS concentrations directly adjacent to these communities will require additional monitoring in order to estimate potential impacts more accurately.

Implementation of mitigation measures to minimise these potential impacts and a monitoring program are discussed below.

6.2 Recommendations

Mitigation measures

The key recommended mitigation measures are listed below and further detailed in the Dredge Management Plan (refer Attachment G9 of EIS Supplement):

- Implementation of a suspended solids management strategy;
- Implementation of ballast water management strategy and risk assessment. Refer to the Marine Facilities Environmental Management Plan (Attachment B4 of the EIS Supplement);
- Minimise the dredge footprint;
- Dredging without overflow from the dredger;
- Reducing the duration of dredging; and
- Dredging at a certain state of the tide.

6 Conclusion and Recommendations

Monitoring Program

- As a first step, it is recommended that suitably qualified taxonomic specialists be engaged to undertake a census of the marine life;
- The monitoring program should be integrated with other monitoring (i.e. water quality, sedimentation studies) and logging equipment should be installed nearby these sites;
- The data collected within this study is suitable for inclusion into an ongoing monitoring program. However, consideration should be given to other monitoring methods (e.g. monitoring of individual colonies, monitoring of target species, etc.);
- It is suggested that as a minimum, at least one survey should be conducted prior to dredging; surveys should be repeated at intervals of no more than two months during dredging; and follow-up surveys should continue until it is determined that the communities have returned to their pre-disturbance condition. As a minimum, there should be at least two follow-up surveys.

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Limitations

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The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

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